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MARINE LITTER: SOCIAL REPRESENTATIONS AND PERSUASION IN SCIENCE COMMUNICATION THROUGH INFOGRAPHICS

Ana Sofia Gomes Teixeira

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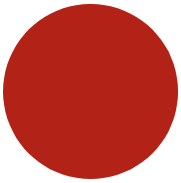

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Ana Sofia Gomes Teixeira

Mestrado em Multimédia da Universidade do Porto

Orientador: Carla Susana Lopes Morais (Professora Auxiliar)

Coorientador: Luciano José Santos Reis Moreira (Assistente Convidado)

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Mestrado em Multimédia da Universidade do Porto

Aprovado em provas públicas pelo Júri:

Presidente: João Carlos de Matos Paiva (Professor Associado)

Vogal Externo: Maria João Santos (Professora Auxiliar)

Orientador: Carla Susana Lopes Morais (Professora Auxiliar)

Resumo

Embora exista atualmente um papel bem estabelecido para a infografia na comunicação científica, não se deu ainda muita atenção às representações anteriores do público sobre os tópicos que elas transmitem, nem sobre como estas representações podem afetar a eficácia da comunicação. Este trabalho visa esclarecer o papel das representações sociais nos níveis de pensamento esforçado e na formação de atitudes dos participantes quando estes processam mensagens persuasivas e de comunicação científica através de infografias digitais, relacionadas com o recente tópico ambiental do lixo marinho. Os participantes foram 313 estudantes universitários pré-graduados da Faculdade de Letras da Universidade do Porto.

Primeiro, de acordo com a teoria das representações sociais, os participantes foram investigados sobre como estão a representar socialmente o tema do lixo marinho e das infografias. Em segundo lugar, foi conduzido um redesenho de uma infografia multimédia sobre o lixo marinho, a fim de esta incluir as representações sociais obtidas dos participantes. Uma infografia sobre o lixo marinho desenvolvida por um jornal Português foi usada como base para o redesenho. Finalmente, os participantes foram aleatoriamente distribuídos para uma de duas condições - na primeira condição, a infografia processada foi a desenvolvida pelo jornal; na segunda condição, a infografia redesenhada, que atendeu às representações sociais dos participantes, foi processada. Níveis de elaboração de ambas as situações foram comparados para investigar se atender às representações sociais dos participantes durante o redesenho da infografia original aumenta os níveis de persuasão nos participantes. Os dados foram recolhidos através de um questionário com questões de associação livre sobre representações de lixo marinho e infografias, uma avaliação de conhecimentos sobre lixo marinho; duas escalas de atitudes relacionadas com o tópico de lixo marinho, e com infografias; e, finalmente, uma avaliação de informação sociodemográfica.

Os resultados sobre as representações sociais do lixo marinho reveralam "morte" como elemento central, associado a "poluição", "plásticos", "espécies marinhas" e "petróleo", indicando que os participantes já ouviram falar sobre lixo marinho, mas não o associam ainda a má gestão por parte do homem, nem consequências para a saúde humana. Quanto à representação de infografia, mais da metade dos participantes não sabia o que era uma infografia, e mesmo entre os que sabiam, a representação revelou “informação” como elemento central, associada a "imagética", "gráficos" e "divulgação", ou seja, a representação está ainda baseada em repetição

de termos, o que revela a incipiência da representação. Os resultados da persuasão revelaram valores mais altos para o processamento da infografia redesenhada, mas apenas surgiram diferenças significativas entre as classificações da escala de conhecimentos.

Este estudo tem particular relevância para as áreas de comunicação multimédia e científica, pois abre caminho para uma melhor compreensão do papel das representações sociais na construção de mensagens científicas e / ou infográficas, bem como das atitudes atuais em relação ao lixo marinho e às infografias.

Palavras-chave: Infografias; lixo marinho; representações sociais; comunicação de ciência; ambiente; atitudes; persuasão.

Abstract

Although there is a current well stablished role for infographics in science communication, not a lot of attention has been given to audiences' previous representations regarding topics depicted in infographics, or how these affect the effectiveness of communication. This research aims to clarify the role of social representations on participants' levels of effortful thinking and attitude formation when these are processing persuasive science communication messages via digital infographics, with a focus on the recent environmental topic of marine litter. Participants were 313 undergraduate college students from the Arts faculty of the University of Porto.

First, in accordance with the theory of social representations, participants were investigated about how they are representing the theme of marine litter and infographics. Secondly, a redesign of a multimedia infographic about marine litter took place, in order to include gathered participants' social representations. An infographic about marine litter developed by a Portuguese newspaper was used as a basis for the redesign. Finally, participants were randomly assigned to one out of two conditions - in the first condition, the infographic processed was the one developed by the newspaper; in the second condition, the redesigned infographic, which attended to participants' social representations, was processed. Levels of elaboration of both situations were compared to investigate if attending to participants' social representations while redesigning the original infographic improved persuasion in participants. Data was collected through a questionnaire with a free association assessment of marine litter and infographics' representations, a marine litter knowledge assessment; two attitudinal scales related first with the marine litter topic, and, secondly, with infographics; and, finally, an assessment of sociodemographic information.

Results on social representations of marine litter brought "death" as a central element, associated with "pollution", "plastics", "marine species" and "petroleum", thus indicating that participants know about marine litter, but aren't associating it with human mismanagement nor consequences for human health. As for the representation on infographics, more than half of participants didn't know what it was; within those who knew, the representation was centered around "information", associated with "imagetics", "graphics" and "dissemination"; that is, the representation was being based on a repetition of terms, indicative of the incipiency of the representation. Results on persuasion showed higher values for the redesigned infographic

processing, but only amongst compared scores on the knowledge scale were found significant differences.

This study has particular relevance for the areas of multimedia and science communication, as it opens the way to a better understading of the role of social representations for construction of scientific and/or infographic messages as well of the current attitudes on marine litter and infographics.

Keywords: Infographics; marine litter; social representations; science communication; environment; attitudes; persuasion.

Acknowledgments

"How far that little candle throws his beams!
So shines a good deed in a weary world."

William Shakespeare

There are – very fortunately – a lot of people to give thanks to, either by their help, by their company, by their patience, by their good will or plainly by their existence, for in fact all of these have helped me to dream about, keep on, and conclude this work.

Very firstly and obviously, I must give thanks to my admirable supervisors, Professors Carla Morais and Luciano Moreira; without their much-appreciated guidance this work wouldn't be the same, nor my enthusiasm on carrying on with it, nor even my ingress on the Multimedia master course.

Great many thank yous to my beloved companions, who so very patiently, humbly and benevolently put up with me and my moods, my stresses, my joys, and my whole self, sometimes giving both body, mind, heart and soul to help me - my boyfriend Miguel, my sister Joana, my mother, my parents-in-law Margarida e Senhor Jorge and, very importantly, my cat Nico.

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Finally, I must give thanks for the kindness and patience of the almost 320 undergraduate students of the same faculty who for number of weeks were constantly bothered on their free intervals at the bar by a girl who so desperately needed them to fill out questionnaires about the oceans' pollution and infographics – truly, without them, this work would not have been possible.

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Abbreviations and Symbols

ABC	Affective, Behavioral and Cognitive
CSS	Cascade Style Sheets
CMS	Content Management System
ELM	Elaboration Likelihood Model
HI	Homogeneity Index
HTML	Hypertext Markup Language
NEP	New Ecological Paradigm
PUS	Public Understanding of Science
SVG	Scalable Vector Graphics

Introduction

Context of the Investigation

The present work aims at studying and applying methods of science and persuasive communication related with a recent and relevant environmental theme – the marine litter case - using for this intent the multimedia tool known as infographics. The study and the work were conducted using as a theoretical foundation the elaboration likelihood model (Petty & Cacioppo, 1986) and the theory of social representations (Moscovici, 1961), in order to focus on the effects of increasing the social meaning of an infographic message and the way it affects the persuasive effect of the message within participants.

Problem, research questions and hypotheses

In today's fast-paced, informational overflowed digital world, efficient communicational tools that are able to offer synthetized and clear messages, capable of attending to public current representations and meanings, are crucial – and science, like many other areas, needs to make proper use of such tools if it aims at reaching and persuading their desired audiences. There are currently not many studies that focus on the role of social representations' theory within science communication practices, and its possible effect on persuasion efficacy.

The purpose of this study is to investigate ways of incrementing the quality and the effectiveness of science communication practices, taking into account social and psychology theories that focus on the way individuals build meanings and attitudes, while putting into practice the communication of the environmental topic of Marine Litter and making use of the multimedia affordances of the infographics format.

As a result, our research questions are the following:

- What are the social representations of participants about the environmental theme of marine litter and about infographics?
- What are the attitudes of participants on the marine litter topic, and on infographics?

Our hypothesis is that:

- When we communicate the scientific theme of marine litter while taking in consideration the social representations of our audience about that theme, we will obtain greater levels of elaboration from participants, when compared to the situation in which the communication of the same scientific theme did not consider their social representations.

Research Methodology

Our research can be subdivided in three main steps:

- First, accordingly with the theory of social representations, participants were investigated about how they were representing the theme of marine litter and of infographics. Addionally, after the development of two attitudinal scales, participant's attitudes on marine litter and on infographics were also assessed (first empirical study).

- Secondly, a redesign of a multimedia infographic about marine litter took place, in order to include the previously gathered social representations on the topic of marine litter. An already published online digital infographic about marine litter, which was developed by a Portuguese newspaper team, was used as a basis for the redesign process (second empirical study).

- In a third step, an experiment was carried out. Participants were randomly assigned to one out of two conditions of infographic processing - in the first condition, the infographic used was the one developed by the newspaper team; in the second condition, the redesigned infographic, which attended to participants' social representations, was used. Levels of elaboration or effortful thinking of both situations were measured and compared in order to understand if attending to participants' social representations while designing infographics for communicating scientific topics improved the persuasion levels in participants (second empirical study).

Structure of the Dissertation

After this introduction to the context, problems, and methods of this research, this dissertation in organized into five other chapters.

The first chapter of the dissertation consists of a review of the literature that was considered relevant for our topic of research: first regarding the topic of infographics as multimedia

representations; then regarding the topic of social representations and of persuasion to science; and finally, regarding the topic of attitudes towards the environment and of marine litter.

Chapters two and three will focus on the two empirical studies carried out during this research. Chapter two will describe the Empirical Study One, which was based on the development and study of attitudinal scales towards marine litter and towards infographics, as well as on the study of social representations related with the same topics. Both methods and results are presented, as well as a final discussion and conclusions of this study. Chapter three will describe the Empirical Study Two, which was based on the redesign of an infographic related with marine litter and on the implementation of experimental studies on persuasion. Methods and results are presented and followed by a discussion and conclusion of the study.

Finally, chapters four and five will provide an overall discussion and conclusions of both studies and their results in the context of the global dissertation's problem, questions and hypothesis, as well as limitions and further research insights.

1. Literature Review

In this chapter a literature review of the fundamental concepts and theoretical foundations for the present work will be described. Also, related works that were found as important additions to the present work are presented and discussed. First, we will discuss the role of infographics as multimedia representations and within science communication. Afterwards, we will discuss the theory of social representations and its potential within science communication. Finally, we will conclude with a focus on attitudes towards the environment and the particular case of marine litter.

1.1 Infographics as Multimedia Representations

As the current digital world is being constantly bombarded with new information at all minutes and at all days, an endless competition for audience's attention and persuasion is on; and if science, among the many other areas, wants to be able to grab their audience's attention, it needs to start making use of more efficient communicational tools, which must be able to offer synthetized and clear messages while still being capable of attending to public specific representations and meanings.

While Vaughan (1993) defined multimedia as any combination of two or more media (for instance text, graphic art, sound, animation or video) that is delivered by a computer - if the viewer of the project or user has the power to control what and when such elements are delivered, then it is interactive multimedia, and if the multimedia you are providing has a structure of linked elements through which the user can navigate, it is hypermedia -, Banerji and Gohos (2010) defined multimedia as "the technical facility for creating, presenting and controlling communication of information through a variety of media in an integrated way" (p.9). If we, as Mayer (2002), shift to the particular focus on the utility of multimedia for learning content, multimedia can then be defined as the presentation of information using words and pictures simultaneously, and we can refer to the author's established multimedia principle, which states that we can better understand information when it is presented in both words and pictures than when it is presented in words alone, because when words and pictures are both presented, learners have an opportunity to construct both verbal and pictorial mental models, and to build connections between them.

During last years, multimedia has been continuing and rapidly evolving, with several innovative multimedia tools and media for communicating, entertaining, teaching and learning

emerging, such as educational videogames, podcasts, animations, infographics, virtual and augmented reality, simulations, or three-dimensional stereoscopic films.

One particular type of multimedia format that has been becoming increasingly popular for communication are the information graphics or, simply, infographics (Dunlap & Lowenthal, 2016). These can be defined as visual representations of complex data that combine graphics, illustrations, text and static or animated images into a format that tells a complete story (Krum, 2013; Polman & Gebre, 2015). Multimedia, digital, online or interactive infographics, although having distinct designations from the printed infographics, both share the principle of utility and visualization of information, but digital infographics have the inherent possibilities of the digital support and of online communication.

Being a type of tool that is characteristic of the 2.0 web environment, infographics are a multimedia format that is identifiable by the aggregation of different multimedia – such as image, video or sound -, by being interactive, and by providing closer communication experiences to the reader (Sousa, 2014). Journalists, as Cook (2013), have emphasized the role of infographics in current days, stating that:

> We find ourselves in the era of big data, a time when information moves faster than ever, and infographics provide us with quick, often influential bursts of insight and knowledge. They are a mesmerizing new way of seeing and understanding our world. (p. 2)

Also, Arroyo (2013) has made clear the importance of infographics in our current society, affirming that:

> Infographics have the functions of representing the world that surrounds us, spread knowledge, sintethize information and to dominate complexity. And all this answers to the human necessity of making everything that surrounds them intelligible, so they can apprehend it. Because comprehension precedes action. In the time that we are living on, in which an authentic avalanche of data is given to us in an incoherent, disorganized and uncontrolled way, to know how to filter it and how to give it a logic structure helps us to make decisions in an optimal way. (p. 347)

The main purpose of an infographic is to efficiently deliver abstract, complex and dense messages in a single and simpler visual format that, while it simplifies and condenses the content being transmitted, it still keeps the message clear and precise, specifically for wider public audiences (Dunlap & Lowenthal, 2016). As Arroyo (2013) stated:

> If we are able to see it, we are able to understand it. Or, as Albert Einstein used to say, "If you cannot explain it in a simple way, then you have not understood it well enough". This is the main goal of an infographic and of data vizualizations: to sintethize a big amount of information in a way that we can understand it clearly in a first glance. (p. 347)

In addition to being capable of simply explaining the complex, infographics have also been proven to increase audiences' engagement with message contents by allowing readers to engage in greater levels of issue-relevant thinking when they read an infographic then when they are just reading text or seeing illustrations that communicate the same content (Lazard & Atkinson, 2015).

Infographics have been increasingly used in newspapers and newscasts in the form of annotated charts, maps, comic strips, and interactive graphics, fueling a rise in narrative visualization or storytelling, with visuals playing a vital role in telling the story rather than simply assuming a supportive role or being a secondary text (Dunlap & Lowenthal, 2016). Cardoso (2010) conducted an investigation that aimed at clarifying the role of infographics in Portuguese journalism. Conclusions showed that Portugal, at the time, was just starting to realize and to uphold this format's affordances, with the first multimedia infographic being posted online in 2001, in Público, followed by Expresso, by 2008, and by Jornal de Notícias, Diário de Notícias, Sol and Correio da Manhã by 2010. This usage of infographics was however still very far from the one verifiable in Spain, in newspapers such as "El País" and "El Mundo". Moreover, some characteristics of infographics published in Portugal, such as the structure of the information shown, still need to be improved. Currently, however, there is already specialized staff in developing infographics in some Portuguese newspapers, like Público (Público, 2018).

In the field of education there has also been an increase in the interest for visual communication tools and for infographics with educators beginning to explore how to use infographics in the classroom. Effective infographics are said to support learning objectives and instructional goals because they involve a type of reading and/or viewing experience that encourages critical thinking and processing, allowing for "infographic thinking" - the cognitive processing of content or a narrative represented and interpreted visually (Dunlap & Lowenthal, 2016).

Infographics' visuals can include static or animated representations. Animations in an infographic can be very useful for the representation of dynamic processes, either spatially or temporally, and in the field of education, this affordance of animated infographics has already been explored (Bellei, Welch, Pryor, & Ketheesan, 2016). An exploratory study of a few science students indicated that they perceive his format as useful for leaning biology (Teixeira, Paiva, & Moreira, 2017). In spite of an increase of interest and published literature on the benefits of visuals and how to best convey data to support engagement, cognitive processing, and conceptual understanding, there is still little research about the benefits and effectiveness of infographics used for educational purposes (Dunlap & Lowenthal, 2016). As Polman and Gebre (2015) concluded in their study on infographics as scientific inscriptions, "much remains to be done in determining contexts and instructional strategies that take advantage of the possibilities inherent in the new genre of infographics" (p. 54).

Although the interest in the infographics format for communication seems to be a recent trend, infographics have been in used for a very long time, accompanying the changes in the views human beings have of what surrounds them – on pre-historic representations, Roman and Greek

aristotelian representations, or even early middle age and middle age's theocentric representations, forms of infographics were already present. But it was specifically in the Renaissance period of human history that changes in the way of thinking and understanding the world, powered by scientific and technologic advances, allowed for representations that aimed at better understanding the natural world – that is, to a spreading of knowledge. Also, the expansion of the press in Europe at that time, with increases in printed reproductions, allowed the reproduction of images as frequent as the reproduction of text. Leonardo da Vinci (Figure 1), for instance, at that time, in his studies, was already trying to join scientific knowledge with graphic and artistic representations, in order to make his complex ideas and constructions more understandable (Arroyo, 2013).

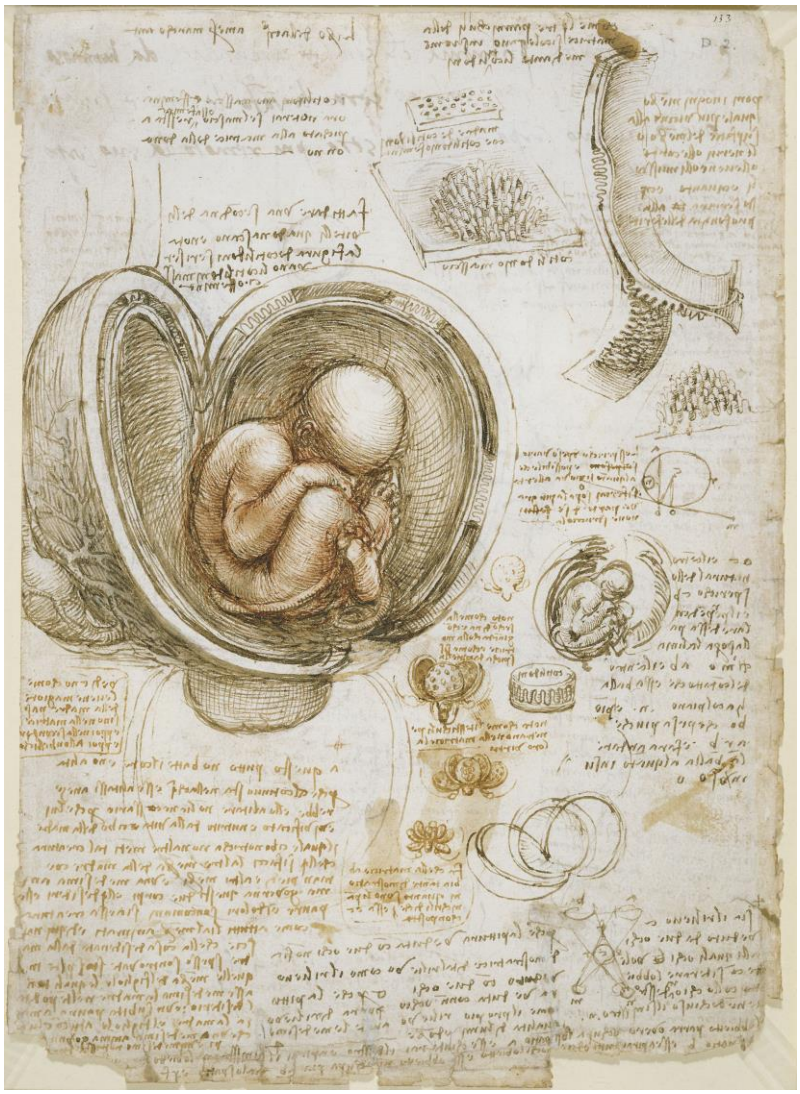


Figure 1 - Study of the fetus in the womb by Leonardo da Vinci.

But the first journalistic infographic is dated of 1806 and was published in the British newspaper The Times with the intention of explaining in a clear way a murder by the Thames

river (Arroyo, 2013). By that century, graphic information rised exponentially, and the visual representations of data also changed, with information shifting from figurative or realistic representations, to more abstract ones.

During the XX century, experts in graphic design helped to improve these abstract representations and schemes. In works such as the one of sociologist and philosopher Otto Neurath with *ISOTYPE* (International System of Typographic Picture Education) or the one of Henry Beck with his subway maps that are used until today, standardized systems of representations based on pictograms or icons started requiring less text to be understood (Arroyo, 2013).

Informatics and the Internet came to revolutionize and multiply infographics' possibilities, leading to the appearance of digital and multimedia infographics. Although in many cases, the goal of transmitting information rigorously is forgotten in order to make infographics more visually appealing or to draw readers' attention, technology brought new possibilities to narrative formulas, adapting to screens and audiovisual languages, and incorporating interactive experiences (Arroyo, 2013; Lazard & Atkinson, 2015). But the current most profound change in infographics is their interactivity in terms of allowing readers to compare, interpret and comment their data. In the words of Arroyo (2013), "[t]he awareness and demand of free access to data from public institutions has led to a civil movement of empowerment of the citizen, that is increasingly informed and capable to claim the fulfillment of rights and duties" (p. 346).

Each infographic attends to a specific content, which is aimed at a specific audience. Therefore, they can be classified in accordance with their goals. Nichani and Rajamanickam (2003) proposed a general classification of web-based infographics according to their communicative intention. They define 4 categories for interactive infographics:

- *Narrative* - Aim at explaining by allowing the reader to get involved with the content which is present in the form of stories narrated from a specific point of view;
- *Instructive* - Aim at explaining by allowing the reader to sequentially follow content, like in the case of step by step instructions or explanations;
- *Explorative* - Give the reader the chance to explore and find content, sometimes by allowing readers to make sense of found content by themselves;
- *Simulative* - Allow readers to experience the intent, generally real-world phenomena.

The authors clarify that the listing order of the categories represents a kind of reader participation continuum that goes from narratives (passive participation) to simulatives (active participation). The authors also proposed that some mixed types of infographics can exist.

Also, Colle (2004) proposed a list of types of infographics, inside a greater group of three categories, according to their goals – (i) scientific or technical, present in scientific texts or technical manuals and based in the simple association and integration of drawings and text; (ii) science communication infographics, aimed at transmitting science and technical knowledge to public audiences and increasingly used in encyclopedias, school manuals, and popular or high-level science communication magazines; (iii) periodic or news infographics, used in the press to help visualize occurrences or descriptions and to include sequential information, like a time-sequence of events. Inside these three main categories, infographics can be of eight types:

- *Infographic diagrams* - Refers to the replacement of histograms by pictograms, more suggestive, easy and fast to understand and memorize. This is the first and most elemental type of infographic;

- *Iluministic infographics* - Refers to infographics in which text is still the most important component, accompanied by pictograms or icons. Generally, these are within a rectangle of verbal and iconic content. The name iluministic refers the style of manuscripts of the High Middle Age, which included illustrations inside the text.

- *Info maps* - Refers to the mere application of cartographic techniques, in which maps, selected pictograms and minimal text are used.

- *First-level infographics* – Do not require side text, as they include text inside them that is self-sustained. Is the most complete type of infographic, composed generally of a title, text, connectors of information and illustrations;

- *Second-level infographics* - Like first-level infographics, but the text is a dynamic part of the infographic, being unnecessary as a separate component and usually appearing over icons;

- *Space-time sequences* - A single graphic showing a spatial sequence as a way of representation of a temporal sequence;

- *Megagraphics* - More complete infographics, with large amounts of information that is neither simplified nor economized – instead, it intents to occupy the totality of a page or pages, in order to accumulate the greatest possible amount of information. Their intention is to summarize information regarding historical sequences, processes or situations. These are more typical in science communication magazines.

- *Mixed-type infographics* – Infographics that combined more than one type of infographics in a single piece.

Since infographics are a type of multimedia communication tool that aims at visually representing something that is complex in a simpler way, they incorporate the concept of representation. In the words of Arroyo (2013), "Infographics go beyond the mere creation of graphics. (…) Their raw material is information, and data is sintethized and transformed into visual codes in a way that with a single look we can understand the reality that they depict" (p.335). In fact, Polman and Gebre (2015) have already referred in their study of infographics' more important aspects that determine their quality as learning tools, that one of these aspects was their use of semiotics and representations. Representations, in particular, graphic representations, help us to communicate abstract concepts like time, space, categories and hierarchy, while also helping us to understand diachronic evolution, situation, relationships between elements and their importance by comparison. The human being has always felt the necessity to communicate visually or graphically in order to explain what cannot be expressed solely by words – such resources have been being used to represent and to better understand what surrounds us (Arroyo, 2013).

The potential of infographics to effective visual communication has been established and has already been put into use. Some fields of application for infographics already made clear by researchers are: in instruction manuals, in business or other institutions' reports, in educational contexts, in science communication, in the news press and in publicity (Colle, 2004). However, their effectiveness has been proven to rely on particular audiences' preferences for consuming information (Buljan *et al*., 2017; Crick & Hartling, 2015). Furhtermore, an infographic approach does not seem appropriate for all types of messages (Dunlap & Lowenthal, 2016). Therefore, there is a need to examine factors underlying users' reading experiences and to clarify to which audiences and types of content the infographics format is best suited, or how it can be improved to fit particular audiences' needs and preferences, in order to develop formats most suitable for capturing readers' attention, accelerating the knowledge translation process and increasing persuasion levels - and this is particularly true for the case of science content consuming audiences.

1.1.1 On Infographics' Design

Researchers have tried to summarize what makes a good infographic. According to Lankow, Ritchie and Crooks (2012), Vitruvius' principles of good design, derived from an attempt to find a timeless notion of beauty that could be learnt from nature's designs, and based on universal laws of proportion and symmetry, serve as the three components by which we attempt to measure the quality of an infographic. Therefore, a good infographic should have all three:

- Utility (*Utilitas*)
- Soundness (*Firmitas*)
- Beauty (*Venustas*)

With respect to utility, such is measured in the way infographics fulfill their objectives within their communication approach; that is, the utility of an infographic is measured by how it enables the communicator to reach its objectives. To measure the quality of an infographic, we must consider the approach used. There are essentially two basic approaches to reach communications goals – explorative and narrative infographics. While explorative infographics provide information in an unbiased fashion, enabling viewers to analyze it and arrive at their own conclusions, narrative infographics guide the viewers through a specific set of information that tells a predetermined story. For scientific and academic topics, the explorative infographics are said to be more adequate, as on these, comprehension of collected research or insights is a priority. (Lankow *et al.*, 2012).

As for the soundness of an infographic, it is considered good when the infographic is communicating something meaningful for the audience, as it provides readers with something of value. As stated by Lankow *et al.* (2012), "If the information itself is incomplete, untrustworthy, or uninteresting, attempting to create a good infographic with it is more than a fool's errand; it's impossible." (p. 198) So, in order to be considered sound, an infographic and its content should relate to its intended audience, whether it is a broad or targeted one, therefore having both meaning and integrity.

As for the beauty or the design component, there are two things to consider: format and design quality. If an inappropriate format is used, the outcome will be inferior. Similarly, if the design misrepresents or skews the information, or if the design is inappropriate given the topic portrayed, it cannot be considered of high quality (Lankow *et al.*, 2012).

Other specialists affirm that accuracy is the most important aspect of an infographic design, that is, data visualizations in the infographic must always match the numbers, as errors on this aspect kill credibility on information depicted and on the expert as an expert (Krum, 2013). Also, they emphasize the choice of a topic to be portrayed – what Lankow *et al.* (2012) referred to as the *soundness* of an infographic – as readers often don't want to waste their time on boring or irrelevant topics, whilst in the middle of information overload and thousands of infographics online. Krum (2013) states that "a good infographic topic focuses on some new piece of previously unknown information related to a subject the target audience is interested in" (p. 281).

Other important aspects of a good infographic design are, according to Krum (2013):

- *Search for prior art* – since as more and more infographics are published online, the more likely it is that a design related to our chosen topic already exists, and we want to make sure our design doesn't repeat what has already been done;

- *Focus on the key message* – to define the key message that we want to communicate to the audience is defining the primary information we want the readers to understand and remember after reading the infographic. Only data and information needed to communicate and support the key message should be included; all rest should be eliminated;

• *Visualize when possible* – the more data readers visualize, the better; making use of data visualizations, charts, graphs, icons, illustrations, and diagrams as design tools to help to make complex information easier to understand for the readers is a top rule, as doing such we are:

  - Grabbing the attention of readers;
  - Reducing the amount of time it takes for readers to understand the data;
  - Providing context to the data by showing a comparison;
  - Making the key message more memorable with the picture superiority effect;
  - Making the information more accessible to readers who speak other languages.

• *Minimize text* – as readers will expect that with the use of visual design, the information will be simpler to understand and faster to read than a traditional text article or blog post, we should fulfill these expectations;

• *Be data transparent* - the infographic needs to address the sources of the data included in the design in an open and honest manner.

The study by Quispel & Maes (2013) on audience's preferences on graphics design revealed that there are differences in preferences for design types between graphic design professionals and lay people in graphic design. While graphic designers rate the attractiveness of non-standard and pictorial visualizations, in which reality is more realistically portrayed, higher than standard and abstract ones, in which reality is simplified, the opposite is true for lay people. As for clarity, both groups prefer standard and abstract (that is, simpler) visualizations, which is reflected in lower response times. This difference in preference for standard and non-standard raises questions about the extent to which graphic designers can indeed bridge the gap between usability and aesthetics in data visualization; as design professionals do not value clarity that much - they value attractiveness more - and it is among designers' tasks to create designs that go in line with the needs of their audiences, this means designers would do well to make sure they test their designs before publishing (Quispel & Maes, 2013).

As Lankow *et al.* (2012) have stated, ultimately, "when it comes to infographic design, the goal of any designer is to establish clarity from complexity" (p. 34).

During this study, a resedesign of an original infographic piece will be put into practice, in order to include previously gathered social representations of a target audience into the design, and to verify if such inclusion can increase persuasion levels on participants who read the redesigned message, in comparison with the original infographic message.

1.1.2 Infographics as Multimedia Representations of Science

Infographics have a significant potential for science communication and education. Pulitzer-prize winning science journalist Cook (2013) has made this clear by stating:

> Science is a field where infographics are particularly useful and powerful, because there is so much drama, but it's often hidden from human eyes or difficult to comprehend. Our quest to understand space is a great example of this – with distances and forces so large it's hard for the average person to make sense of what has been discovered. What is it like to land on Mars? How alone are we in the Milky Way, truly? These are questions that demand visual answers. (p.78)

The communication of scientific and technologic knowledge to public audiences has generally been recurring to visual formats to facilitate comprehension. Either in science communication magazines or in the media, opportunities for teaching new knowledges or discoveries are eminent with the use of infographics (Colle, 2004). Additionally, since a science infographic can reach a very large audience, especially if in digital format, these are particularly adequate for science and environmental communication, conveying information both quickly and effectively (Lazard & Atkinson, 2015). In fact, multimodal infographics are increasingly frequent in science communication and, as a consequence, some research has already been made in order to elucidate the potential of this format for communicating science.

Polman and Gebre (2015) studied ways to determine the quality or effectiveness of infographics as scientific inscriptions, by using six infographics and presenting them to 10 individuals with expertise in science, graphic/information design and learning sciences. Results showed that the main aspects of quality that science infographics should have were: (i) clarity of its purpose; (ii) proper way of addressing an intended audience; (iii) quality of their organization or design; (iv) adequate use of semiotics and representations; (v) quality of their data; and, finally, (vi) credibility of their sources. In a study that intended to study persuasion levels' variation in individuals who were shown pro-environmental infographics, text-based messages and illustrations, Lazard and Atkinson (2015) concluded that individuals engage in greater levels of issue-relevant thinking with infographics than with other formats.

However, in the particular field of science communication, infographics do not always seem to increase audience's knowledge retention, in relation to a text-based method. A study with infographics for the communication of health information to students, consumers and doctors revealed no differences in knowledge retention between the infographic format and text-based format. However, even if both formats have proven to be equally effective in terms of information transfer, users perceived their usefulness differently, with the infographic format being perceived as more enjoyable for reading and more user-friendly than the written format (Buljan *et al*., 2017). Another work with infographics for the communication of scientific research results related with health was that of Crick and Hartling (2015), in which the infographics format was compared with the critical appraisal format for communication to an audience composed of health researchers and professionals. Results have shown that while infographic and critical appraisal formats were equally preferred, the two formats were preferred for different reasons and for

different audiences. The critical appraisal format was preferred in terms of clarity and was found to be directive, professional, and concise; the infographic was preferred for aesthetic appeal, being classified as visually engaging and easy to read while capturing a lot of information. As for the preferred formats for different audiences, participants revealed that the infographic could be more useful to patients and their caregivers, the public and the media, while the critical appraisal format was believed to be more appropriate for researchers and research funders. Also, an analysis by a professional group showed that nurses preferred the infographic while physicians preferred the critical appraisal. These findings stress out that there is a need to consider the target audience when developing scientific summaries via any format, and that certainly includes the infographics format.

Nevertheless, infographics do seem to have the potential to be an effective knowledge translation tool for the transfer of scientific research results (Crick & Hartling, 2015). The work of Sousa (2014) was related with science communication via infographics and intended to measure the effects of multimedia infographics in the understanding of scientific news. After distributing the same science content related with the malaria disease in both text-based and multimedia infographic format, it was verified that the group that used multimedia infographics retained better the information presented, as they answered a great number of questions related with the content correctly. The author concludes that digital infographics offer a greater communicative efficacy than mere text-based news. The possibility of interaction and reaction, the possibility of manipulation according to readers' time and comprehension levels, the possibility for exploration and the signage or animations of multimedia infographics allow for readers' appropriation of the information and increments their attention and autonomy while consuming science and technology information (Sousa, 2014).

In popular and public science media, science infographics have already become frequent. The United Nations Environmental Programme has recently invested in a series of full reports entirely filled with infographics accompanied by blocks of text for the communication of environmental issues – the Vital Graphics (UNEP & GRID-Arendal, 2016). The National Geographic magazine has a long history with science infographics since its first publications (Wiedemann, 2016). Popular science blogs like Tabletop Whale are entirely dedicated with the publication of science related infographics (Lutz, 2017) (Figure 2). Also, in Portuguese media, newspapers are currently including more infographics into their publications, and several of them are related with science topics like nature conservation, climate change, ocean pollution or biodiversity (Público, 2018). Scientific magazines such as Nature and Scientific American have also already been recurring to infographics to communicate with their audiences, reuniting specific teams dedicated to creating information graphics, who affirm to believe that science infographics are an engaging way to appeal to a wide and non-specialist audience. In an article published on *nature.com* by Jackson (2014), elements of such teams affirm that:

Graphics can often communicate scientific concepts more efficiently than words, for any audience. Visuals that are developed for a science savvy but non-specialist audience (…) can help make scientific findings accessible to broader audiences. By removing barriers (such as technical jargon), and providing context (…), the information is presented in an immediately intuitive and engaging manner. (p.1)

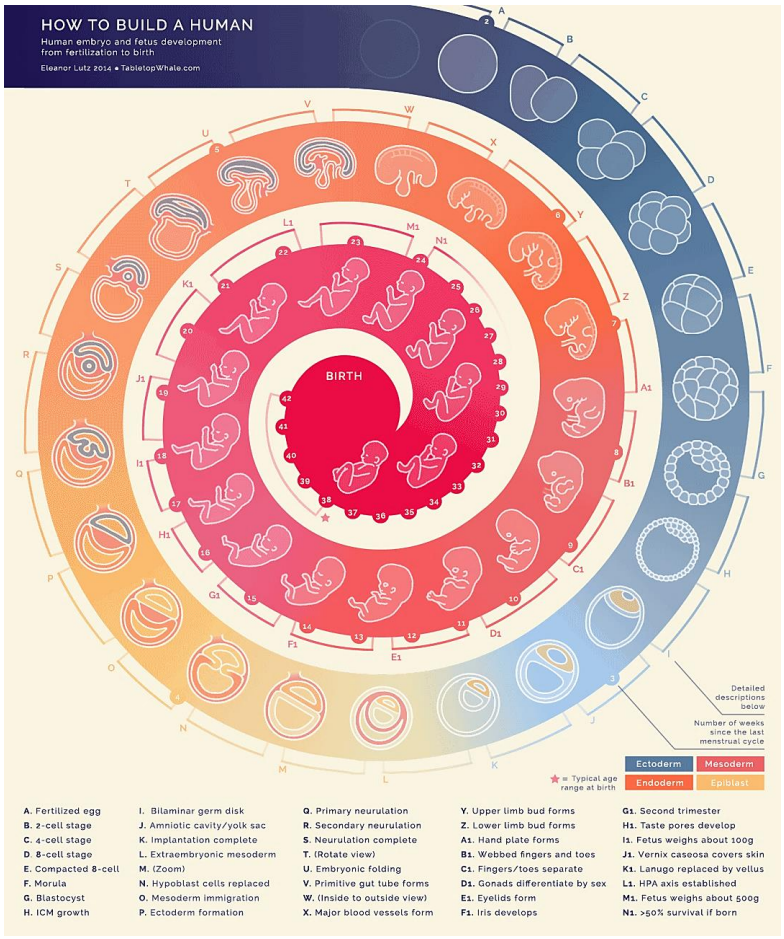


Figure 2 – Example of a science related digital infographic found online (Lutz, 2017).

Also, in science education, infographics have been researched in terms of perceived usefulness and effectiveness as a learning and teaching tool. Teixeira, Paiva, and Moreira (2017) studied the usefulness of animated infographics for learning biology topics, using infographics available online to gather opinions of former and/or current biology students. Results showed that participants found these multimodal resources useful for teaching and learning purposes, particularly because of (i) their facilitating effect for understanding complex topics, (ii) their usefulness as an introductory or reviewing tool of content, and (iii) their easing of visualization of abstract scientific concepts or processes. In another study regarding the production and use of animated infographics to teach immunology, inquired students agreed that these tools improved their understanding of basic concepts, made the topics more enjoyable to learn, and were valuable

resources for reviewing the course material (Bellei, Welch, Pryor, & Ketheesan, 2016). Other authors such as Yildirim (2016) and Ozdamli, Kocakoyun, Sahin, and Akdag (2016) recently also inquired students regarding infographics' usefulness as an educational tool and concluded that they perceived the format as a good support of text materials and as facilitators of learning and remembering important content, including in the field of science learning. Also, factors such as aesthetics and visual quality are mentioned by students as an important factor for educational infographics, although these seem to play a secondary role (Teixeira *et al*., 2017; Yildirim, 2016).

Colle (2004) observed that "Infographics have, in a way, been present in science since its beginnings (…) and science has, without a question, been their main root" (p. 15) So, there is already a well established and eminent role for this format in the learning and in the communication of science. However, most studies that intend to connect infographics and science learning and/or communication have been focusing on opinions rather than on results at either cognitive or attitudinal levels. Also, not a lot of attention has been given to specific audiences' previous representations regarding the topics depicted in infographics, and how these might their affect effectiveness of communication and persuasion. This work intends to fill this gap, by studying both audience's social representations about the scientific topic of marine litter, as well as studying variations in levels of issue-relevant thinking that might occur while assimilating science related infographic information.

1.2 Social Representations and Communication of Science

1.2.1 Social Representations

During the process of communication, whether it is communication of science or of another area of expertise, there is always present the importance of what Burns *et al*. (2003) referred to as "meaning making" – that is, the importance of attending to the social, cultural and political conditions in which we are communicating. This is particularly true to the communication of science, where science facts lose meaning and use for society unless they are socially significant. Attending to the social representations of an audience certainly is a way to better understand and construct the social meaning of science theories and facts. Therefore, to make use of such knowledge would make science communicators more able to communicate to particular audiences in more effective and socially meaningful ways.

Social representations, or the theory of social representations (Moscovici, 1961), actually began with a study regarding a scientific topic. Serge Moscovici's initial intention was to study what the French public knew about the scientific theory of psychoanalysis, particularly in relation to what happens when a scientific theory becomes common knowledge. But there was a broader implication for Moscovici's work – the idea that individuals do not just collect and process

information, but that they also build meanings and theorize social reality - the notion of how individuals build a significant world. Moscovici (1961) proposed the social representations as the way individuals and societies build meaning of what surrounds them. This said, social representations are not only applicable to the particular phenomenon of the diffusion and appropriation of scientific theories or concepts by laymen, but instead, they have a more universal scope, and can be applicable to also to cultural objects, ideologies, experiences or simply to daily communications. To study social representations is, therefore, to analyze the processes through which individuals, in social interaction, construct theories about social objects, which make viable the communication and the organization of behaviors within the group (Vala & Monteiro, 2004). Moscovici (1981) himself provided a definition for social representations as

> (…) the collection of concepts, propositions and explanations created in daily life and resultant from interindividual communication. They are the equivalent, in our society, of myths and systems of beliefs of traditional societies; they can also be seen as the contemporary version of common sense. (p.181)

This definition comprises two essential characteristics of social representations. First, social representations are social constructions that characterize and are presupposed in all human interactions. Representations are not created by individuals in isolation. In the words of Moscovici (2000):

> "Always, and everywhere, when we encounter persons or things, and become acquainted with them, such representations are involved. The information we receive, and to which we try to give a meaning, is under their control and has no other significance for us than what they give it." (p. 78)

Second, social representations, as they consist of social constructions, are built and developed within specific social groups, and they reflect a representation of an object only within a certain culture and at a particular point in time (Farr, 1993).

Later, another definition for social representations was given by Jodelet (1989a): "(…) a modality of knowledge, socially elaborated and shared, with a practical objective and that contributes to the construction of a common reality within a social group" (p. 36).

Such definition brings us to a third essential characteristic of social representations – their functionality. Social representations contribute to build and to orient communication and behavior within a social group, offering programs for communicating and acting in relation to objects that constitute interrogations within the group (Vala & Monteiro, 2004). They are a "practical knowledge" (Jodelet, 1989a).

The main function of social representations is to attribute meaning or to significantly organize reality, but this function can be decomposed in four sub-functions: (i) social causality or explanation of social events; (ii) behavior justifications; (iii) social differentiation and (iv)

communication. In social causality or explanation of social events, the relationship between causal attribution and social representations can be looked upon two lenses: in the first, attributions are seen in a context of meta-representations about Man, its behavior and what happens in human society; in the second, attributions about a behavior or social phenomenon are studied in the context of the specific representations about that behavior or social phenomenon (Vala & Monteiro, 2004). Regarding the function of social representations for behavior justifications, Vala and Monteiro (2004) state: "In a controlled or automatic way, conscient or inconscient, a great number of our behaviors corresponds to our representations" (on our own translation from the Portuguese original). As for the function of social representations in social differentiation, it is easy to understand that, if the specificity of a social group contributes to the specificity of their representations, and since social representations also conduct the group's behaviors, they also contribute to the differentiation of social groups. As for the function of social representations in communication, it has already been clarified that social representations act as the basic support of interindividual communications (Moscovici, 2000; Vala & Monteiro, 2004), therefore they are capable of having a role within science communication.

It is in the context of collective sharing, socially regulated production and communicational and behavioral functionality that social representations should be understood as a phenomenon (Vala & Monteiro, 2004). This is in fact a particular point that distinguishes the initial views of Durkheim and of what this author called "collective representations", and that of Moscovici (2000) (Vala & Monteiro, 2004). Collective representations, as viewed by Durkheim (1898), were distinct from individual representations, and were defined as "social productions that were imposed to individuals as exterior forces, served social cohesion and constituted phenomena as diverse as religion, science, myths and common sense" (Vala & Monteiro, 2004), (our own translation from the Portuguese original). While Durkheim looked at collective representations as explanatory devices that were known to exist in societies, but whose functions, inner dynamics and structure were not important – in sum, as a concept - Moscovici (2000) understands these representations as a phenomenon, adding two qualifications to the concept of collective representations: "Social representations should be seen as a specific way of understanding, and communicating, what we know already" (p. 31) and "Durkheim (…) has a rather static conception of these representations (…)". What Moscovici (2000) meant was that social representations occupy a position between concepts, with the purpose of abstracting meaning from the world and introducing order into it, and percepts, which reproduce the world meaningfully. Moreover, Moscovici (2000) meant to stress out that representations have a mobile and circulating character, that is, they are plastic, not static, and that "once created, (…) they lead a life of their own, circulate, merge, attract and repel each other, and give birth to new representations, while old ones die out". Finally, Moscovici (2000) concludes that:

> (…) if, in the classic sense, collective representations are an explanatory device, and refer to a general class of ideas and beliefs, (…) for us they are phenomena which need to be

> described and to be explained. They are specific phenomena which are related to a particular mode of understanding and of communicating – a mode which creates both reality and common sense. It is in order to stress such a distinction that I use the term "social" instead of "collective". (p. 33)

As stated by Moscovici (2000) "the purpose of all representations is to make something unfamiliar, or unfamiliarity itself, familiar" (p. 33). Such endeavor is carried on through two main processes - anchoring and objectifying - that culminate with a formed and more stable social representation–. While the first process strives to anchor strange ideas, reduce them to ordinary categories and images in order to set them in a familiar context, the second one attempts to objectify them, by turning something that is abstract into something that is almost concrete – "to transfer what is in the mind to something existing in the physical world" (Moscovici, 2000, p. 34).

Anchoring precedes and follows objectifying, first setting reference points for the creation of the new representation, and later giving the representation a social function that will organize the individual's social relationships. It is also through anchoring that new representations are created using the old ones as anchors – assimilation -, but, at the same time, that the old representations are re-elaborated because of the new representations that they helped creating – accommodation (Vala & Monteiro, 2004).

Objectifying organizes the elements that constitute the representation and gives them materiality. It has three basic processes:(i) selective construction, in which there operates a selection or reduction of the new information to something more brief and useful, as well as a accentuation of some of the representation's elements that are majorated and made nuclear; (ii) schematization, in which operates an organization of the previous elements into a pattern of structured relationships amongst them; and finally, (iii) naturalization, in which the concepts retained and their relationships are constituted as natural categories, and the previously abstract becomes concrete (Vala & Monteiro, 2004).

Later on, Abric (1994) proposed an organization of social representations that includes two systems of meaning – the central nucleus or central system, and the peripheral system, or peripheral elements. The central system is described as being rigid, coherent, stable, consensual, determinant of the homogeneity of the group and is connected to their collective history. The central nucleus determines the organization of the representations and generates meaning for their elements. On the other hand, the peripheral elements of a representation are more flexible, changing according context and integrating personal experiences. Therefore, they allow for social representations to include individual divergences, and, so, it is the peripheral system that manifestes the heterogeneity of the social group, having as a function the contextual adaptation of the representation and the protection of the central nucleus, as they allow for individual divergences to keep organized around a central nucleus that is nevertheless unique within the social group (Vala & Monteiro, 2004).

The work of Salesses (2005) offered pertinent observations regarding the role of attitude in the structuration of social representations. Previous conclusions from Moscovici (1961) had already noted the existence of a circular and interdependence relationship between attitudes and social representations – while attitude is taken into consideration when the elements of a social representation are taking form, attitude is also affected by already stablished social representations. Salesses (2005) stresses the importance of attitude for social representations stating that " (…) la représentation est dépendante des attitudes dans la mesure où l'on s'informe et l'on se représente un objet uniquement après avoir pris position à son propos" (p. 472). As for the effect of social representations on attitudes, the author mentions one of Moscovici's conclusions regarding the topic - "lorsque le sujet exprime son opinion sur un objet, nous sommes tenus de supposer qu'il s'est déjà représenté quelque chose de ce dernier" (Salesses, 2005, p. 473). Therefore, there appeared to exist a co-construction of attitudes and social representations.

Also taking into consideration the work of Abric (1994), Salesses (2005) stresses out that while changes in attitude are capable of interfering with the peripheral elements of a social representation, the central nucleus remains independent from attitude changes. Therefore, social representations appeared to have an effect on attitude forming, but changes in attitudes didn't seem to be capable of changing social representations, in their core; if they operated a change in an individual's attitude and the effect of such change reached the central nucleus of a social representation, the social representation wouldn't change – instead, a new one would be created, with a new central nucleus (Salesses, 2005). The author carried on a study to clarify the role of attitudes in social representations in their initial formation, this is, before there exists a central nucleus and a representational field fully developed. This would be in line with the initial point of view of Moscovi's, regarding the circular interdependency of attitudes and social representations, and the effect of attitudes on social representations during their genesis, or structuration process; after the fully establishment of a social representation, however, changes in attitudes wouldn't have a significant effect on social representations. Conclusions of the work carried on by Salesses (2005) came to provide evidences for the effect of attitude on the structuration process of social representations. While positive attitudes towards a certain social object acted as accelerators of the structuring process of its social representation – individuals with positive attitude regarding the social object were more able of identifying central elements of the social representation that was being constructed – on the other hand, negative attitudes towards the social object resulted in a less organized representational field of the social representation, and, therefore, acted as a blockage to the establishment of the social representation (Salesses, 2005).

The study of social representations, although not very used currently within studies of science communication, has a history of connection to science. Farr (1993) has already concluded, more than 20 years ago, that the theory of social representations is perfectly suited to the empirical investigation of the public understanding of science, and that scientists should take such theory

seriously if they wanted their informed advice to be heard by public institutions and governments. Farr (1993) stated that "[w]hen any scientific theory diffuses within a culture it changes the nature of that culture" (p. 189) In fact, the concept of social representation opened the way to a new kind of knowledge about the cognitive and symbolic activity of individuals in their daily interactions – not only in relation to the appropriation of science topics, but instead in relation to the appropriation of any social object. The formation and function of social representations, as practical social theories about particular social objects, via the processes of objectivation and anchorage, adds a functional and practical purpose to social representations, which are manifested in their conduction of behaviors, communicative activities, argumentation and daily explanations, and in the differentiation of social groups (Vala & Monteiro, 2004).

The social representation of a scientific theory, process, or discovery is not the theory, process or discovery itself, but instead has a mere relation to it – it is in fact a representation of a representation. While scientific theories or processes consist of representations of the natural world as understood by the scientists that studied it, the social representation of the same object in common sense will consist of a new representation build upon the scientific one. This way, the scientists, or the science communicators, who are interested in promoting the public understanding of science and science communication as a whole, should be aware of both the scientific and the social representation of the topic they are addressing, as they are usually interested in correcting the social representation, so it matches the scientific one (Farr, 1993).

It is in line with Farr's viewpoint that the present work intends to study audience's social representations. As we understand that gaining knowledge about the social representations of science of the public will allow for better understanding and management of public attitudes towards science topics and, also, increment the quality of science communication practices, we will conduct an investigation that aims at studying audience's social representations in relation with the environmental topic of marine litter,.Then we will compare if attending to such representations will increment or not audience's levels of issue-relevant thinking on the presented information, while operating changes in public attitudes towards the subject.

1.2.2 Science Communication

Communicating science is not just about scientists talking about their works to public audiences. Instead, as Burns, O'Connor, and Stocklmayer (2003) explained, the term science communication reunites in itself the aims of many science-society interactions and terms, such as public awareness of science (PAS), public understanding of science (PUS), scientific culture (SL) and scientific literacy (SL). The study of attitudes, persuasion and "common sense", although coming from areas of expertise different from those of natural sciences, add significance to all the aims of science communication, therefore the relevance of the current investigation for science communication.

Public awareness of science aims at developing awareness and positive attitudes or opinions towards science; public understanding of science, in its turn, aims at developing public comprehension of meanings and implications of science contents, processes and social factors. Moreover, the expression scientific culture aims at promoting a society-wide environment that appreciates and supports science and scientific literacy. Finally, the term science literacy refers to the ideal scenario where people are aware, interested, involved in and forming opinions about science, while seeking to understand it (Burns *et al*., 2003). Burns *et al*. (2003) also summarized the aims of scientific awareness, understanding, literacy and culture and, therefore, the whole purpose of science communication, into the label and vowel analogy AEIOU for desirable personal responses to science, namely:

- A stands for awareness of science;
- E stands for enjoyment or other affective responses to science;
- I stands for interest in science;
- O stands for the forming, reforming or confirming of opinions or attitudes related to science;
- U stands for the understanding of science, in its meanings and implications.

After defining and determining the goals of main science communication related terms, Burns *et al*. (2003) defined the broader term of scientific communication as "the use of appropriate skills, media, activities, and dialogue to produce one or more of the AEIOU (the vowel analogy) personal responses to science". They also pointed out, and in line with the definition proposed by Bryant (2003), that science communication can be defined by "the processes by which the culture and knowledge of science are absorbed into the culture of the wider community" – but that science communication is not just a process. For it to be effective, it must always have predetermined and appropriate aims – such as the AEIOU analogy for desired personal responses to science, that, ultimately, if achieved from the target audience, prove the effectiveness of the communication of science.

But why to communicate science? Burns *et al*. (2003) emphatize the results from surveys that have suggested that the public does not know much about science, and that, in turn, scientists don't know much about the public. If we take into account that science communication, as defined before, implies dialogue, then we are able to understand that the more we communicate science, the more public and scientists get to know each other, and so, the more we can improve such communications. Also, as Burns *et al*. (2003) clarify, effective communication of science affords one or more of the AEIOU responses from the participants' side, but the science communicators involved must be provided with one of these responses as well, otherwise such communication is not considered effective.

Recent surveys also suggest a significant interest from the public in science related topics, with about 4 out of 10 Americans stating they are very interested in science and medical

discoveries (National Science Board, 2018), 8 out ten UK citizens agreeing that science is a big part of their lives and that all should take interest on it (Ipsos Mori, 2014), and more than 50% of Australians stating that they are very interested in science or science-related topics, with a predilection for health issues and new medical and scientific discoveries (Lamberts, 2017).

According to Bultitude (2011), there are both cultural and motivational factors compelling the communication of science. Cultural factors have influenced the separation of science from society, and therefore have increased the need for scientists to engage with public audiences. The author listed four key cultural factors:

- Reduced recognition of expertise and authority of scientists;
- Changes in knowledge production and interdisciplinarity;
- Proliferation of communication channels and sources of information;
- Democratic deficit.

Reduced recognition of expertise and authority of scientists is related with the significant shift in how the public trust and defer to expertise in relation to science topics, which was claimed to happen due to scientists increasing reliance on funding from industrial and private sources, disagreements between respected scientists on either side of relevant scientific arguments such as climate change, nuclear power or genetically modified foods, or examples of scientific fraud highly covered by the media (Bultitude, 2011). On the other hand, changes in knowledge production and the interdisciplinarity in the actual scientific sphere have lead to research developments and great science projects that require multiple inputs from different areas of expertise, as well as greater resources and funding, which, particularly in times of economic hardship, might lead to a difficulty in some public groups to appreciate and support such scientific endeavors. Also, the proliferation of communication channels and sources of information has created a need for an adaptation and stimulation of science communication, for with the increased use of technology, the advances in computing and in connectivity, both inside and outside the schools, the use of technology has enhanced several collaborative engagement opportunities via blogs, podcasts or social media, that could and should be used for communicating and discussing science with the public. Finally, the democratic deficit also increases the need for science communication. Changes in the political-scientific decisions, which are increasingly made outside the public arena, have been leading to a public disconnection with democratic process and voter apathy. That, in the case of decision making for the distribution of funds to science, creates an important need for the public to be aware of the importance of investing in science, and, therefore, calls for the communication of science, as it will move voters to participate more on the decisions regarding a distribution of funds for science (Bultitude, 2011) .

Regarding the motivational factors for science communication, Bultitude (2011) distinguishes institutional and strategic motivations from individual motivations. Institutional and

strategic motivations are motivations highlighted by institutions and national bodies to justify their support for science communication, and are based on four key arguments:

- Utilitarian argument, focusing on the gaining of technical skills and knowledge by the people involved, which will be useful to them in other areas of their lives;
- Economic argument, focusing on the fact that advanced societies require technologically skilled workforce and that science contributes to the overall output of a region;
- Cultural argument, focusing on the shared heritage of science, as a wider part of our culture;
- Democratic argument, focusing on the importance of instructing the public to interpret basic science in order for them to be able to participate in major decisions in society that involve science.

At the individual level, Bultitude (2011) mentions that, for individual science researchers, communicating science motivations and benefits are related with skills development, career enhancement, research quality and impact's enhancement, new research perspectives, higher personal and institutional profile, influence and networking opportunities, new collaborations and partnerships' formation, enjoyment and personal reward, additional funding, increasing awareness of the value of research to society, increasing student recruitment and inspiration for the next generations of researchers. But there are also the so called altruistic motivations, in which scientists' motivation for communicating science is related with a sense of duty, the raising of awareness to science or the transmitting of the importance of science.

There are two basic distinct approaches for communicating science that comprise a fundamental concept for all models of science communication – these are the deficit and the dialogue or contextual approaches (Bultitude, 2011). According to the deficit approach, there is an assumption that the audience members lack knowledge of scientific concepts and, therefore, science communication occurs from the scientists to the public audience, that is, it is assumed that the public has inadequate knowledge and that science has all the required knowledge, and so science communication is practiced in a one-way flow, from science to public (Bultitude, 2011; Burns *et al*., 2003). On the other hand, the dialogue or contextual approach involves a two-way exchange of information, or dialogue, between scientists and the public, that explores the interaction between science and the members of an active public that "have local knowledge and an understanding of, and personal interest in, the problems to be solved" (Bultitude, 2011). The definition of science communication proposed by Burns *et al*. (2003), which includes dialogue as a main constituent of science communication, goes in line with the contextual approach, following the example of more recent science communication tendencies.

There are three main forms of media used for communicating science and engaging audiences: traditional journalism, live or face-to-face events and online interactions, each with associated pros and cons (Bultitude, 2011).

Traditional science journalism can be either printed or broadcasted, for instance via newspapers, magazines, TV shows or radio programmes related to science. This medium has the advantages of being able to reach large potential audiences, of producing high quality material thanks to an overview by journalism professionals, of being traditionally recognized as an agenda setting, and of allowing audience selection via choices of publications or programmes. On the other hand, the medium also presents disadvantages, such as a lack of control from the part of the scientist on how the media covers the scientific work, a tendency for one-way communication or the fact that it usually provides only a limited or superficial focus.

As for the medium of live or face-to-face events, it includes public lectures, science centres and museums, scientific debates or dialogue, science busking, sci-art, science cafes or science festivals. Its main advantages are the more personal and direct interaction between the communicator and the public, the greater control on the side of the scientist of the communication's content, the presence of a two-way communication, and the frequent partnering with external organizations that add complementary expertise to the activity. However, there are also disadvantages, like limited audience reach, the requirement of intensive resources that lower activities sustainability, and there is the potential inconveniency of attracting only audiences that had a pre-existing interest on the topic.

Finally, the medium of online interactions for science communication includes science related websites, online journalism, blogs, wikis, podcasts, social networking and citizen science activities. The advantages of this medium are the potential to reach large audiences, the possibility of allowing direct interaction between public and science communicators, the control on the side of the science expert on the content (or at least on the initial content) of the communication, the possibility to let the audience's preference decide on a one-way or a two-way communication and the fact that this medium allows for always accessible content, suiting the audience's time preferences. Disadvantages of this medium are the one related with the encouragement of superficial interactions, the later difficult control on how the content is picked up by other people, the requirement of regular attention to the activity, in order to maintain profile, and the requirement of key communication skills that may not be immediately apparent.

1.2.3 Persuading to Science

As science communication activities occur in the "real world", their outcomes require and can be understood more deeply while using skills and methods from social sciences (Burns *et al*., 2003). As said earlier, changing attitudes towards science is one of the aims of science communication (the O vowel for opinions/attitudes related to science), and the studies on attitude changing are carried out within social theories on persuasive communication (Lima, 2004).

One way of changing attitudes is via persuasive media messages, which studies have begun since the propaganda during World War II (Lima, 2004). However, studies have concluded

on a limited effect of these messages on forming and changing attitudes; the conversations amongst the social group that followed the processing of such messages would, as well, have effects on the changing of attitudes towards an object – therefore, there are multi-step flows on the effects of persuasive communications (Lima, 2004). This conclusion emphasizes the need of these types of messages to have social relevance for the groups which they are aimed at, as they are to be discussed within the social group after processing One way of doing such thing could be by constructing these messages in a way that includes their social representations on the communicated objects within the persuasive messages.

Developments on the investigation of persuasive communication has concluded that the effects on persuasive communications are neither immediate nor simple has they seemed to be. Effects at several levels, as the source of information, the channels, the messages and the type of audience affect persuasion (Lima, 2004). Sources that maximize persuasion are those who are seen as more credible, more attractive and more socially similar with the audience. As for characteristic of the messages that might increase persuasion are their moderated appeal on fear, as well as conclusions left inexplicit (Lima, 2004).

As a result, models on persuasive communication have emerged, which presuppose that the impact of persuasive communications occur in five steps, and, if any of those fail, the whole process fails – (i) attention to the message; (ii) comprehension of the message; (iii) accepting of message arguments; (iv) retention of message; and, finally, (v) behavior consequences (Lima, 2004).

However, with so many variables appearing as affecting persuasion of communications outcomes, models that simplified the cognitive processes leading to persuasion were developed, including the Heuristic-Systematic model (Chaiken *et al*., 1989) and the elaboration likehood model (ELM) (Petty & Cacioppo, 1986). Both models share the idea that persuasion is not always the result of a long, cognitive process that involves effort, such as the five steps mentioned earlier. Sometimes persuasion occurs via shortcuts, that is, individuals do not cognitively elaborate very much on the message in order to accept it. These models refer two types of cognitive processing of persuasive messages – a peripheral or heuristic processing, which involves less cognitive effort; and a central or systematic processing, involving cognitive elaboration of messages within more or less the same five steps previously discussed (Lima, 2004; Chaiken *et al*., 1989; Petty & Cacioppo, 1986).

Some of the "short-cuts" often used during peripheral processing are the trusting on communications given by specialists or by people which we like or the belief that, the greater length of arguments it presents, the more trustworthy the message is or, even, the usage of statistics and graphics that "don't lie" (Chaiken *et al*., 1989). The difference between these two models relies on what causes the peripheral or heuristic processing to happen – while Chaiken *et al*. (1989) stand by an automatic activation of less elaborated processing, Petty and Cacioppo (1986) stand by a simply inferior level of effort or elaboration when peripheral processing happens, without any automatisms. Therefore, this model stands by a continuum of elaboration

(degree to which a person thinks on the arguments of a message) that goes from inferior levels – peripheral processing – until it reaches, or not, higher levels – central processing. According to both models on persuasive processing, changes on individual attitude within two different persons might happen towards the same end, but with different pathways.

The ELM is a widely used persuasion processing model and a social psychology theory that intends to describe how changes in individuals' attitudes are processed in persuasive communications (Lazard & Atkinson, 2015; Petty & Cacioppo, 1986). This dual-process model describes individuals' attitude change via persuasive information processing as a consequence of either high or low levels of elaboration that occur via central or peripheral processing routes (Figure 3).

Elaboration, in this model, is defined as the extent to which a person thinks about issue-relevant arguments of a message, and high or low elaboration levels will differentiate between central and peripheral processing of persuasive messages information. While the central processing route involves effortful thinking, leading to individual's critical evaluation of a message content, against prior knowledge and experiences, the peripheral processing route leads to less thinking effort and, therefore, does not involve a careful consideration of messages (Petty & Cacioppo, 1986). These distinct routes for persuasive messages processing, and consequent elaboration levels, will lead to different types of attitude formation. Attitudes that follow central processing will be more predictive of behavior as well as more enduring and resistant to change, since the individual has thought more and used more resources to build such attitude. On the other hand, attitudes that follow peripheral route processing of messages are unpredictive of behavior, as well as less enduring and more prone to change as the individual is presented with counter-persuasion attempts (Lazard & Atkinson, 2015; Petty & Cacioppo, 1986). The extent of elaboration with which a message is processed can be viewed as a continuum that goes from no thought about the issue-relevant information presented in the message, to the complete elaboration of every argument, and complete integration of these elaborations into the person's attitude schema.

The ELM (Figure 3) identifies two basic conditions that are determinant for elaboration likehood – capacity and motivation. That means that individuals less motivated or interested on the topic will more likely process the message peripherally, if there are peripheral clues in the message (good sources, good length of arguments, etc), and the opposite will happen for more interested individuals (Petty & Cacioppo, 1986; Lima, 2004). Already identified factors affecting motivation are the need to be precise on the judging of the message (if there are some responsibilities associated with the resulting attitudes of processing the message, higher elaboration generally occurs); the individual personality characteristics (if an individual likes to think more profoundly on problems, they have more probability of engaging on higher elaboration) and the auto monitorization level of the individual (that is, how much importance the

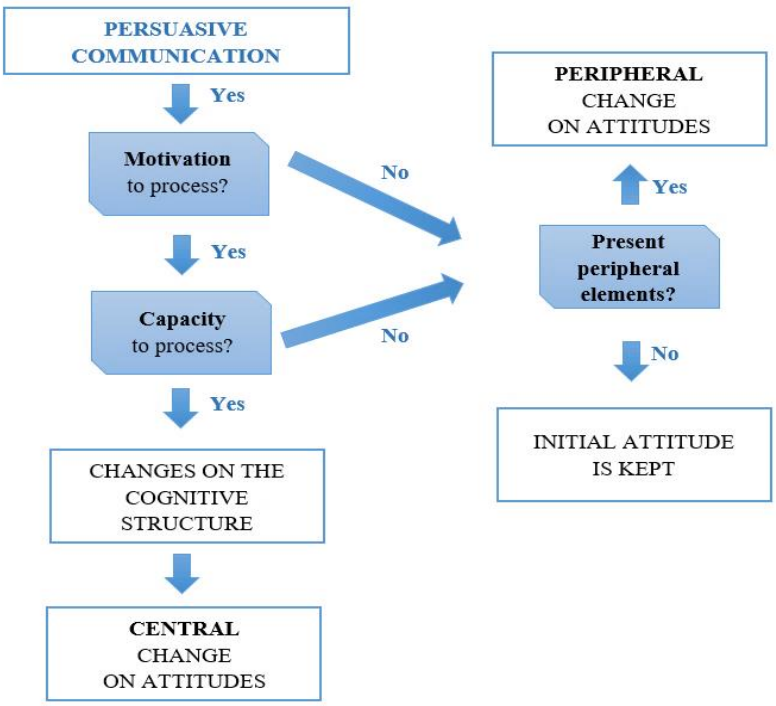


Figure 3 - Schematic representation of the ELM (elaboration likehood model). Adapted from Lima (2004).

individual gives to what others might think – if the individual exhibits high auto monitorization levels, it is more likely to engage on lower elaboration levels) (Lima, 2004). As for capacity, it includes aspects such as individual concentration possibilities, knowledge levels or information processing capacities. That is, the existence of distractors might conduct to more peripheral processing; the higher knowledge on the topic increases the likehood of central elaboration; and, finally, higher individual capacity for reading and interpreting graphic and technical information also increase the likehood of high elaboration (Lima, 2004).

While the ELM focus on attitude change due to persuasive message processing, it is important to define the term attitude used in this model. Petty and Cacioppo (1986) clarified the concept of attitudes as:

> (…) general evaluations people hold in regard to themselves, other people, objects, and issues. These general evaluations can be based on a variety of behavioral, affective, and cognitive experiences, and are capable of influencing or guiding behavioral, affective, and cognitive processes. (p.123)

Later on, the authors provide an example of how behavioral, affective and cognitive experiences and processes relate to attitude change and formation:

> (…) a person may come to like a new political candidate because she just donated $100 to the campaign (behavior-initiated change), because the theme music in a recently heard commercial induced a general pleasantness (affect-initiated change), or because the person was impressed with the candidate's issue positions (cognitive initiated change). Similarly, if a person already likes a political candidate he may agree to donate money to the campaign (behavioral influence), may feel happiness upon meeting the candidate (affective influence), and may selectively encode the candidate's issue positions (cognitive influence). (p.127)

Regarding the relationship between the ELM and recent visual communication techniques, as Lazard and Atkinson (2015) explain, the ELM and other theoretical frameworks about message processing tend to focus only on text-based messages, not taken into account individual's perception of both visual and textual elements of a message as a whole in a first glance. It has already been recognized that images surpass words for attitude formation and change, especially in persuasive political campaign messages, and also that images are more persuasive than text or speech messages (Griffin, 2008; Lazard & Atkinson, 2015). Since we are currently living in an era where visual mass media messages proliferate, it is of significant importance that we find ways of integrating and applying persuasion models like the ELM to the new media of visual communication in order to better understand their power and effectiveness as persuasive message communicators.

The ELM model has been used in the past to study audience engagement in issue-relevant thinking when they are introduced to infographic messages that communicate environmental topics, and the results from such study demonstrated that pro-environmental communication through infographic messages resulted in greater elaboration levels, and, so, that infographics are effective media to communicative persuasive environmental messages (Lazard & Atkinson, 2015). The current work intends to make use of infographics to communicate pro-environmental messages related to the marine litter topic, in order to explore the relationship between this instrument of visual communication and audience's elaboration levels and attitude changes in

relation to the topic of marine litter, and if those are affected or not by the inclusion of social representations of the audiences into the infographic design.

1.3 Attitudes towards the Environment: The Marine Litter Case

1.3.1 Attitudes towards the Environment

As far back as in the 1970s, the environmental questions became a relevant topic for society, and, as a consequence, social science authors were already publishing works and developing attitude measure scales concerned with the study of how people thought about nature and the environment (Castro, 2005).

By 1978, Weigel and Weigel were one of the authors that were concerned that due to the nature and severity of the environmental deterioration caused by humans, changes at the technological and, more importantly, at the attitudinal and behavioral levels were necessary to solve such a dilemma. The authors particularly focused on the need for a change of attitudes and behaviors towards the environment as "certain patterns of consumption, land use, and waste behavior are both disruptive to the ecosystem and, in the long run, incompatible with the survival of the individual, the species, and the planet" (Weigel and Weigel, 1978, p. 4). Such statements can still be heard today by environmentalist communicators. In fact, a lot of money and effort has been currently spent in pro-environmental communication in the media, with the same objectives as those mentioned by Weigel and Weigel (1978), that is, to promote pro-environmental behaviors and change attitudes about the environment, particularly in relation to the acquisition, consumption and disposition of consumer products. Nevertheless, effective motivation of audiences to adopt environmental-friendly behaviors is challenging (Lazard & Atkinson, 2015), and also, just measuring individuals' environmental concern is not the same as measuring their behaviors, which means that while people might reveal significant levels of environmental concern, that does not necessarily mean that they would be willing to act upon the preservation of the environment (Castro, 2005).

The field of behavioral sciences and psychology has been contributing to the area of the environmental studies by developing a considerable number of scales that intend to access public environmental concern. The three most important and used scales are the scale for the measurement of ecological attitudes and knowledge by Maloney, Ward, and Braucht (1975), the scale for environmental concern by Weigel and Weigel (1978) and the New Environmental Paradigm (NEP) scale by Dunlap and van Liere (1978). The scale for the measurement of ecological attitudes includes measures for environmental concern, knowledge, willingness to act and measures of past and present behavior. In its turn, the scale for environmental concern attempts to measure audiences' concern with the environment by referring to a number of

environmental problems. Finally, the NEP scale makes reference to a set of attitudes that are more linked with values or with visions of the world, using a set of items that stand for a pro-ecological vision of the environment together with another set of items that stand for an antagonist and anthropocentric vision of the world (Castro, 2005). The NEP scale has been widely used by investigators, whose criticisms and reflections have contributed for a later reformulation of the same - the New Ecological Paradigm scale - with an improved equilibrium between pro and anti-ecological items.

The NEP scale intends to measure if the audience supports a pro-ecological view of the world, and this view derives from one of the main models for the study of the environmental concern and the environmentalism of the public, the Human Exemptionalist Paradigm – New Ecological Paradigm or simply HEP-NEP model (Dunlap & van Liere, 1978). This model proposes an explanation for the changes within sociology and the public due to "new problems involving the quality of our air, water and land" (Castro, 2005, p. 180) that are continuously being discovered, to the human negative impact on the physical environment and also to the threats that such impact poses to the health and welfare of human beings (Castro, 2005).

According to the HEP-NEP model, the general public is changing the way they think about the environment, and this trend has in fact been proven by several studies around the world (Castro, 2005; Dunlap & van Liere, 1978). The change that is said to be occurring goes from a Dominant Western Worldview (DWW) and a Human Exemptionalist Paradigm (HEP), to a New Ecological Paradigm (NEP). While the DWW thinks of humans as dominant in relation to other creatures on earth, and the world as a vast place with unlimited opportunities for humans, the HEP, on the other hand, stands for a vision where humans differ from other species because of their cultural and genetic heritage and sees the social and cultural environment as crucial for humans, while the biophysical environment is irrelevant for the humankind. Contrastingly, the NEP vision looks at humans as an exceptional species, but nevertheless as a species among many others on the planet, which are interdependent in a global ecosystem, and that people live and depend on a finite biophysical environment that inputs powerful constraints. According to the authors, such changes in the way the public sees the environment would be a consequence of the growth of human societies for the last 400 years thanks to colonization and the emergence of new technologies that opened the way to new resources, and of the 1970s growing of conscience about the end of this "era of exuberance" and the new "era of scarcity" within a global ecosystem that is finite and with ecological laws to which humans cannot escape (Dunlap & Catton, 1979). While results from the HEP-NEP model and the consequent NEP scale applications all around the world have indicated a high level of concordance with the pro-ecological vision of the environment, it does not seem to mean that people are adopting more pro-environmental behaviors and that their willingness to invest time and energy into activities that aim to preserve or to improve environmental quality is increasing (Castro, 2005).

According to recent reports on public attitudes towards science, the level of concern for specific environmental topics is high, namely in the United States of America (National Science Board, 2018) and in Australia (Lamberts, 2017). While in America 7 out of 10 people reveal a high level of concern with water and air pollution, considering it as dangerous or very dangerous, they, however, express less personal interest in the overall topic of environmental pollution – only 4 out of 10 people say they are very interested in environmental pollution - and this interest has been decreasing since 1990 (National Science Board, 2018). In Australia, environmental issues are one of the top topics in which the public is very interested in, with a measured rate of 51% (Lamberts, 2017).

One function of attitudes is to orient behaviors (Lima, 2004). However, while at a first sight attitudes and behaviors would be seen as coherent, studies dated as far back as 1934 have been proving that it is possible and actually frequent that measured individual attitudes do not agree with individual behaviors (Lima, 2004). In the specific case of environmental attitudes, a study of Wiegel and Newman (1976) has concluded that attitudes towards the environment could show bigger correlation with pro-environmental behaviors only if these behaviors were more generic and not so specific (like recycling or signing petitions).

The study of public attitudes towards the environment is of particular importance to this work. According to the attitude definition proposed by petty Petty and Cacioppo (1986), which emphasizes their capability of influencing or guiding behavioral, affective, and cognitive processes, the study of an audience's attitude towards recent environmental topics such as the topic of marine litter, together with the usage of the ELM for studying persuasion and attitude change levels, will help to better understand how the audience is thinking about the topic and to find ways to better modulate our discourse about the environment to reach these audiences, and also might help predicting audience's pro-environmental behaviors.

1.3.2 Marine Litter

Marine litter or marine debris are expressions used on the media and in scientific literature to refer to the human created waste that has been discharged into coastal or marine environments all around the globe. It is defined as "any anthropogenic, manufactured, or processed solid material (regardless of size) discarded, disposed of, or abandoned in the environment, including all materials discarded into the sea, on the shore, or brought indirectly to the sea by rivers, sewage, storm water, waves, or winds" (UNEP & GRID-Arendal, 2016, p. 6). While according to UNEP

Figure 4 – Cover of a recent *National Geographic* maganize dedicated to plastic pollution (National Geographic, 2018).

and GRID-Arendal (2016), the most common items of marine litter found in beaches are cigarette butts, bags, remains of fishing gear, and food and beverage containers, in reality, any human-made object that doesn't naturally degrade in a short period of time could potentially become marine litter if not properly managed, and so, we find, as the most common litter items, materials that are made of paper, wood, textiles, metal, glass, ceramics, rubber or plastic.

Plastic is the most frequent component of marine litter, sometimes accounting for 100% of floating litter (Galgani, Hanke, & Maes, 2015) and between 60 and 100% of accumulated litter on shorelines, sea surface and sea floor (UNEP & GRID-Arendal, 2016). Bigger fluxes of plastic litter are usually found near areas of more intense urban activity and shore or coastal use, but natural ocean currents also enable the existence of accumulation areas in oceanic convergence zones, and on the sea floor (Galgani *et al*., 2015). The large-scale accumulation of marine debris has attracted worldwide media attention (Figure 4), which often refers to these areas as "great

garbage patches". The biggest currently described "garbage patch" is the "Great Pacific Garbage Patch", described in the media as a "marine trash vortex", but others have been reported in the Atlantic and the Indian oceans, as well as in smaller bodies of water, such as the North Sea ("Great Pacific Garbage Patch", 2014). However, these marine litter accumulations are not being accurately depicted, as they are actually much larger spans of the ocean, with millions of km^2, which borders are diffuse and changeable. Also, the dominant component of these marine litter accumulations are tiny pieces of plastics that are not visible to the naked eye, instead of larger and visible litter items.

The fact that almost 100% of the litter found on marine environments all over the world is plastic is not a surprise, since plastic is a material that has become a constant in our society, to the point of our current period of human history being called "The Plastic Age" (Cózar *et al*., 2014; Wagner *et al*., 2014). Plastic has brought significant societal benefits, but also serious environmental concerns, related with their post-use management and consequent accumulation in aquatic and non-aquatic environments (Wagner *et al*., 2014). Although plastics have not been around for a long time, as they only began to be mass produced in the 1950s – they already have become a worldwide phenomenon, with as many as 8300 Mt of plastics produced until today, and around 3900 Mt of this amount produced only in the last 13 years. Since the 1950s to 2015, in only a 65-year period of time, global production of the most common plastics – resins and fibers – increased from 2 Mt to 380 Mt.

Plastic production is in fact "extraordinary", and has already surpassed all other man-made materials' production (Geyer, Jambeck, & Law, 2017). Plastic's current largest market is packaging (42%), followed by the building and construction sector (19%). China is currently accounted for 28% of resins' global production, and 68% for fibers' global production (Geyer *et al*., 2017). Of all plastics ever made, it is estimated that a total of 6300 Mt of plastic waste was generated until 2015, and within these, only 9% was recycled, 12% incinerated and the remaining 79% ended up in the environment, either in landfills or in the open environment. If production and waste management of plastics remain the same, it is estimated that by 2050, 12,000 Mt of plastic waste will be in the environment (Geyer *et al*., 2017).

The problem about plastics is not as much the amount of it that is being produced currently, as it is their very own characteristics as a material and their fate after being used. In fact, as the first global analysis of all mass-produced plastics ever manufactured carried on by Geyer *et al*. (2017) concluded, "[t]he same properties that make plastics so versatile in innumerable applications - durability and resistance to degradation - make these materials difficult or impossible for nature to assimilate". Plastics are in fact all petroleum-based synthetic materials. The vast majority of monomers used to make plastics are ethylene and propylene, which derive from fossil hydrocarbons (Geyer *et al*., 2017). Plastics are composed of long chains of polymeric molecules that are created from organic and inorganic raw materials like carbon, silicon, hydrogen, oxygen and chloride, and these materials are usually obtained from oil, coal

and natural gas. Plastic means malleable or flexible, and in fact this material can be molded into virtually any shape; they are also inexpensive, lightweight, strong, durable and corrosion-resistant (Ivar do Sul & Costa, 2014).

As plastics make up the largest proportion of litter pollution – the majority of plastic items found are packaging items, fishing nets and pieces of unidentifiable plastic or polystyrene – this means that this litter can take hundreds of years to break down or may never truly degrade (Galgani *et al*., 2015). None of the commonly used plastics are biodegradable, so, instead of decomposing, they only accumulate in the environment. The only way to permanently eliminate plastic waste is by thermal treatments, like combustion or pyrolysis (Geyer *et al*., 2017). There are three possible fates for plastic waste – recycling/reprocessing, thermal destruction of discarding in landfills, or open dumps or in the natural environment. Recycling doesn't avoid final deposition of plastics in the environment, it only delays it - it can only reduce future plastic waste generation if it displaces primary plastic production, but because of its counterfactual nature, this displacement is extremely difficult to establish. Also, contamination and mixing of polymer types generate secondary plastics of limited or low technical and economic value. As for thermal destruction of plastic waste, it mostly occurs by incineration, which has environmental and health impacts, unless proper control technologies and incinerators' design and operations are used. Only recently, has pyrolysis emerged as a new solution that extracts fuel from plastic waste. Globally, recycling rates for plastic waste have slowly increased from 18% to 24%, with Europe having the highest recycling rate (30%), followed by China (25%). In the US, however, recycling rates have remained low (9%) since 2012, after a phase of increment; the rest of the world follows this same trend. As for incineration rates, they have been also increasing, except in the US. Europe also has the highest rate (40%), followed again by China (30%), and the US decreased their rate to 16% in 2014. The rest of the world follows the same rate as the US (Geyer *et al*., 2017).

While on one hand plastics' light weight and durability are characteristics that make them adequate for a very wide range of products, on the other hand, their intense consumption, rapid disposal and inappropriate management after usage has been leading for years to an extensive accumulation of plastics in the environment. These are found particularly in the marine environment, where plastic fragments of various sizes and with various origins have been found on all major ocean basis, and ultimately could affect several marine and non-marine species, through plastic ingestion or entanglement (Cózar *et al*., 2014; Geyer *et al*., 2017; Wagner *et al*., 2014).

A recent and more specific concern regarding the accumulation of plastics in marine and non-marine environments is the one related with microplastics, that is, smaller than 5 mm fragments of plastic that result from the disintegration of bigger plastic fragments that experienced prolongated UV exposition and other environmental conditions such as physical abrasion (Wagner *et al*., 2014). A significant number of recent studies have demonstrated that microplastics are present within every marine habitat, either spread at the surface of oceans, in

the water column and in sediments, even in the deep sea, with concentrations at the water surface ranging from thousands to hundred thousands of particles km^{-2} (Andrady, 2011; Browne, 2015; Galgani *et al*., 2015; Ivar do Sul & Costa, 2014). But microplastic debris is proliferating, migrating and accumulating in other natural habitats, "from pole to pole and from the ocean surface to the seabed; (…) on urban beaches and pristine sediments" (Ivar do Sul & Costa, 2014, p. 12).

Microplastics can have origin in the fragmentation of bigger plastic fragments (classified then as secondary microplastics), but they can also be originally produced as microplastics (primary microplastics), which is the case of fragments of plastic present in resin pellets or in personal care products like shower gels and peelings (Wagner *et al*., 2014). In fact, while in the 1990s liquid hand-cleansers were a minor source of microplastic pollution and were rarely used by consumers, by 2009 the scenario had already changed, with the average consumer likely using microplastic-containing products on a daily basis – and the polyethylene microplastics that these products contained, with a modal size of <100 microns and, therefore, ready to be immediately ingested by planktonic organisms at the base of the food chain, are not captured by wastewater plants and, so, have being entering the oceans until today, getting smaller due to UV light exposition and absorbing hydrophobic materials such as PCBs, becoming more toxic in the long-term (Fendall & Sewell, 2009).

The presence of microplastics in the marine environments has already been extensively reported, as well as their concentrating effect of pollutants in water and their bioavailability and contamination via ingestion of a wide range of marine organisms (Andrady, 2011; Ivar do Sul & Costa, 2014; Wagner *et al*., 2014). Because microplastics have a larger surface area to volume ratio than macroplastics, they are more susceptible to contamination by a number of airborne pollutants. Also, because they are made of highly hydrophobic materials, chemical pollutants become concentrated onto their surfaces, and so microplastics act like reservoirs of toxic chemicals in the environment (Ivar do Sul & Costa, 2014). Browne (2015) has defined four global types of sources of microplastics: larger plastic litter, cleaning products, medicines and textiles. One of the reasons for this concern with microplastics is the greater danger of passive or active ingestion by animals that these fragments represent, since their micro dimensions make them invisible and imperceptible to theirs and our own eyes, and also increases the chances of their presence in several surfaces, waters and even on air. It has been proven that organisms at every level of the marine food web ingest microplastics, and those inhabiting industrialized areas are exposed to higher amounts of these particles (Ivar do Sul & Costa, 2014). Additionally, there is the danger of microplastics adsorbing several organic contaminants and hazardous chemicals, that also enter animal food webs by ingestion, and could ultimately reach our own species via ocean-originated products (Karami *et al*., 2017; Wagner *et al*., 2014).

If animals eat microplastics that have been previously contaminated, they become susceptible to physical damage, while also contributing to bioaccumulation to top predators and primary or secondary consumers. In fact, microplastics have already been detected in seafood like

clams or fish, as well as in the commercial salts of 8 different countries (Karami *et al*., 2017), products that humans consume on a daily basis. The North Pacific Ocean is currently the ocean basin with the higher amounts of buoyant microplastics, probably because of the existence of more land masses and higher development of the Northern Hemisphere, in comparison with the Southern Hemisphere. But microplastics are not only present in water – the shores of six continents have also proven to be contaminated with microplastics (Ivar do Sul & Costa, 2014).

The solutions for the handling of the ubiquitous presence of microplastics in our environment are currently drawn to two major issues – how to proceed with source control and methods to address the environmental passives of the last 60 years. However, very close and restricted circles prioritize source control accordingly with the 5Rs (*Refuse, Reduce, Reuse, Recycle, Rethink*), and microplastics simply cannot be sieved from sands nor filtered out of seawater, as it would take forever (Ivar do Sul & Costa, 2014).

The relevance of this concern is already being made visible through several recent news in Portuguese media - and also in the rest of the world - related to the topic of microplastics, where attention is being called for the microplastics in the grains of salt we put daily in our food (Freitas, 2017), in the tap water we consume daily in our homes ("Água da torneira de todo o mundo contaminada por microplásticos," 2017), and in the bodies of the greater species of our oceans, in quantities that can go up to 800 kilos of plastic in the body of just one whale ("Microplásticos são "grande ameaça" para os gigantes dos oceanos," 2018). Although the community seems to be more or less aware of the problem, it must nevertheless be guided to look for alternatives to reduce the consumption of plastics, to improve the handling of their plastic waste and to make better choices as consumers of plastic. Guidance by the public sector, independent world conferences that coalesce knowledge and actions, implementation of educational programs, urban and rural facilities cooperation and, above all, persuasion through practical examples of proper control of waste are proposed ways to overcome community habits of consumption of plastics. But also state polices control of sources and calculation of environmental value losses due to microplastic pollution could be solutions, as well as a complete cradle-to-grave approach to plastics (Ivar do Sul & Costa, 2014). As Ivar do Sul and Costa (2014) conclude, after reviewing more than 100 works on microplastics marine pollution,

> Microplastics will continue their slow, intricate paths towards the bottom of the ocean and ultimately become buried in sand and mud for centuries. However, rather than despair, scientists should propose solutions that can be considered by academia, society and industry. (p. 23)

As a matter of fact, since the beginning of this investigation, a *boom* on communications related with marine litter became very evident; either on documentaries specifically related with

Figure 5 – Example of an illustration related with marine plastic pollution that circulates on social media (https://thelittleworldofliz.com/).

oceans and ocean plastics pollution (Brownlow, Honeyborne, & Fothergill, 2017), Facebook groups entirely dedicated to this topic (PlasticOceans, 2018), entire magazines and websites dedicated to marine plastic pollution (Figure 4) (*National Geographic*, 2018), as well as several news on television and newspapers (Parker, Jacobs, Elliot & Treat, 2018; Zachos, 2018), and even comics and other illustrations inspired by the prevalent presence of plastics on the sea are frequently found circulating on social media (Figure 5). As a result, many positive outcomes of the dissemination of the topic of marine litter have also been visible, including recent news that reveal future political actions against the proliferation of marine and non-marine plastic pollution, by applying taxes to plastic bottles prices (Cardoso, 2018).

As science and journalism communication of this topic have revealed to be an effective solution, it becomes also important to study ways of improving and encouraging communication on the microplastics and plastics topic to non-specialist audiences, in order to increase even more the public knowledge on the topic, and to promote bigger changes on their attitudes. With that in mind, the present work intends to study how the better understanding of the audience's social representations on the topic of marine litter and of plastics can help improve the levels of

engagement and persuasion to pro-environmental and marine litter related communications, ultimately guiding to stronger and more enduring changes of attitude regarding the environmental topic of marine litter and plastic consumption. As the effectiveness of visual content and of multimedia media for learning and for persuasive communication has already been established, the medium chosen for this work was that of infographics.

2. First Empirical Study: Attitudinal Scales and Social Representations

Attitude measure scales concerned with the study of how people think about nature and the environment have been being developed since the 70s (Castro, 2005), with the intention of promoting changes on attitudes and behaviors of humans towards their patterns of consumption, waste production, among others of many human-carried actions that have been permanently affecting our environment (Weigel and Weigel (1978). Currently, the three most important and used environmental scales are the scale for the measurement of ecological attitudes and knowledge by Maloney, Ward, and Braucht (1975), the scale for environmental concern by Weigel and Weigel (1978) and the NEP (New Environmental Paradigm) scale by Dunlap and van Liere (1978). For the present work, however, none of these attitude scales was felt as ideal due to their strong ideological assumptions, and none was focused on the topic of marine pollution in particular – so a new attitudinal scale regarding the environmental topic of marine litter was developed.

Considering Rosenberg and Hovland's (1960) multicomponent model of attitudes, those are composed by affective, behavioral and cognitive (ABC model) components, and all three components influentiate an individual's evaluation of an object. While the affective component of attitudes refers to an individual's feelings or emotions linked to the object, the behavioural component refers to past behaviours, experiences regarding that object, and behavioural intentions; finally, the cognitive component refers to the beliefs, thoughts, and attributes that we would associate with the object. Taking such into consideration, the developed attittudinal scales towards the objects "Marine Litter" and "Infographics" incorporated items which referred to the ABC components of attitudes.

Scales on attitudes towards the increasingly popular format of infographics have not been found during the process of review of literature. Therefore, the investigator also developed a new attitudinal scale towards this communication format, taking into consideration the ABC

components of attitudes proposed by Rosenberg and Hovland's (1960). This new scale, if proven effective, will contribute to the development of this and other future research on the topic of multimedia infographics.

Gaining knowledge about the social representations of a science topic within a specific audience could allow for a better understanding of how public audiences are building their ideias towards science topics, and, ultimately, such information could also help to increment the quality of science communication practices. Therefore, this study intends to conduct an investigation that aims at studying the social representations in relation with the environmental topic of marine litter, within a specific, and non-specialist in science topics, audience. This study gains relevance when we consider that the study of an audience's attitudes towards recent environmental topics such as the topic of marine litter, and the study of the social representations that are being constructed around the same theme, could ultimately help communicators to better understand how such audience is thinking about this particular topic and, ultimaly, help finding ways to better modulate the discourse of science communication messages regarding this and other similar environmental topics, in order to increase the efficiency of communication with audiences. By also focusing on the attitudes of the audience towards infographics, we can deepen the knowledge on infographics amongst Portuguese students, while also gather information on how this audience is looking at this format, as it would be the one used to present the information on the topic on marine litter.

2.1 Methods

In this section we will describe our group of participants, as well as the instruments that were developed and used on further parts of the study. Finally, we will describe the procedures applied to conclude this study.

2.1.1 Participants

Participants were undergraduated students of the Faculty of Arts, of the University of Porto. A total of 313 students were used for this study. Their ages varied between 18 and 62 years old (M = 22.61; SD = 5.71), and the sample included 223 females and 90 males.

2.1.2 Instruments

In the next sections the instruments developed and used for the First Empirical Study will be described, beginning with the two attitudinal scales developed – one related with the topic of

marine litter, and the other related with attitudes towards infographics – and finalizing with a description of the final questionnaire, developed for the data gathering phase of this study.

2.1.2.1 Attitudinal Scale One: Attitudes Towards Marine Litter

The developed scale (Appendix A - Final Questionnaire for First Empirical Study) included 31 items, in which were included items related with the ABC components of attitudes (10 items associated with the affective component, 10 items associated with the behavioral component, and 11 items associated with the cognitive component), all built around the theme of marine litter or the environment. The answer options followed a 7-point Likert scale (1 – Strongly disagree; 2 – Disagree; 3 – Partially disagree; 4 – Neither agree nor disagree; 5 – Partially disagree; 6 – Agree; 7 – Strongly agree).

2.1.2.2 Attitudinal Scale Two: Attitudes Towards Infographics

The developed scale (Appendix A - Final Questionnaire for First Empirical Study) included 29 items, in which were included items related with the ABC components of attitudes (8 items associated with the affective component, 11 items associated with the behavioral component, and 10 items associated with the cognitive component). The answer options followed a 7-point Likert scale (1 – Strongly disagree; 2 – Disagree; 3 – Partially disagree; 4 – Neither agree nor disagree; 5 – Partially disagree; 6 – Agree; 7 – Strongly agree).

2.1.2.3 Final Questionnaire

The final questionnaire (Teixeira, Morais, & Moreira, 2018) (Appendix A - Final Questionnaire for First Empirical Study) was completed with the inclusion of four free association questions, which asked participants to indicate around five words or ideas that came to their minds when they thought of four word/stimulus: “marine litter”, “plastics”, “environment/nature” and “infographics”. A fifth question asked participants to rate their answers’ importance, from one (least important) to five (most important); when, however, participants mentioned more than 5 answers, they would add a six or seven to this scale of importance of their answers. The last questions on the questionnaire were added to gather sociodemographic information from the participants.

A knowledge scale on marine litter was also added to the questionnaire. A total of 14 questions with multiple choice answers were constructed, using as a basis the information provided by an online infographic about marine litter and plastics that would further be used for the second empirical study (Firmino & Rodrigues, 2017). This scale intended to gather data on the knowledge that our participants had on the topic of marine litter.

2.1.3 Procedures

In the following sections we will discuss the procedures that were applied during this study. First, we will describe the procedures used for the development and construction of the attitudinal scales for marine litter and for infographics. Later, we will describe procedures for the gathering and analysis of data regarding both attitudes and social representations, within our participants.

2.1.3.1 Development of the scales

Taking on Rosenberg and Hovland's (1960) ABC model of attitudes, a series of 30 affective, behavioral and cognitive items were constructed (10 items per component). After performing face validity with another two authors, items were adjusted to enhance clarity of the items. Two pilot studies were also carried on, using a sample of 24 participants, in order to test the scales and the overall questionnaire. After these pilot studies, some items and the organization of the questionnaire were readjusted in order to enhance even more its clarity to our participants. Final attitudinal scale on marine litter included 31 items, while the final attitudinal scale on infographic included 29 items (Appendix A - Final Questionnaire for First Empirical Study).

2.1.3.2 Data gathering

Participants were mainly approached directly during their free intervals of classes, at the Faculty of Arts bar, frequented by a great number of students, on a daily basis. First, the intention of the study was explained to participants. Afterwards, the investigator asked the participant if they wanted to participate on the study. There was a great adherence from the participants on the participation of the study. Some professors and experts at the Faculty of Arts were also contacted in order to obtain their permission to use a free time on their classes to gather some participants or to plan collaborations in order to facilitate the gathering of participants. Three professors accepted the gathering of data during their classes time. Permission for this gathering during classes time was also asked and granted from the Director of the Faculty of Arts.

2.1.3.3 Data analysis

In order to be able to test the final attitudinal scales reliabity and factor analysis, it was tried to reunite the maximum number of participants, in order to have a total of 10 participants per item of the scale (310 – that is, ten participants per item on the final scales). After that number was achieved, the analyses Principal Component Analysis, with Varimax with Kaiser Normalization and Cronbach's alpha were conducted using the SPSS software (version 25). We used an alpha level of .05 for all statistical tests.

As in the case of the gathered data on social representations, the investigator performed a content analysis of a total of 259 questionnaires and of 4393 answers. This number differs from that of total participants as 54 participants either didn't answer to the social representations part of the questionnaire (4), or they were also participants on the later second empirical study (50), and so their condition of social representations' gathering was different. After the written data was digitally coded, it was organized into groups of similar sentences, words or synonyms. The investigator conducted the initial coding, which was latter reviewed for consistency by an expert. Later, words or sentences that only were mentioned by one participant or that were mentioned less than four times were removed from these groups (Valentim, 2003; Moreira, 2012; Martins, 2017). Descriptive statistics, such as the homogeneity index (HI), number and frequencies of occurrences of terms and mean importance positions - obtained from the mean of the importance that participants gave to each of their answers - were obtained using *Microsoft Office Excel*. The HI consists of the division of the total number of different terms by the total number of mentioned terms; a lower HI value thus indicates that there is a consensus in the terms referred by participants (Moreira, 2012). The HI was calculated before and after the removal of the terms that only appeared once, to better understand if this removal did not falsely conduct us to more homogenous group of mentioned terms; the smaller the difference between the before and the after HI, the smaller the change in homogeneity of the group of mentioned terms operated by this removal.

Analysis of possible central and peripheral elements on the social representations were also made (Abric, 1994). While the central nucleus of a representation is constituted by the most frequent and the most important classified elements, as indicated by individuals within a social group, contrasting elements of a representation include elements stated by few people but that they consider them very important. On the other hand, peripheral elements are those which are ranked as less important by individuals; among these, while the first periphery contains the most important elements of the periphery of the representation, the second periphery comprises secondary elements that are not very present and not very important in the representation – therefore, they comprise the least frequent and least important elements referred by participants (Abric, 1994; Vala & Monteiro, 2004; Monaco *et al*., 2016).

2.2 Results

Results will first be present in relation with the attitudinal scales on marine litter and on infographics. Later, results on the social representations studies will also be presented.

2.2.1 Attitudinal Scale towards Marine Litter

Factor analysis revealed that the sampling was adequate, as the Kaiser-Meyer-Olkin Measure of Sampling Adequacy was of .875, $p < .001$. Bartlett's test of sphericity was significant

($\chi 2$ (465) = 3201.90, $p < .05$). Factor analysis began with all items of the scale, with total variance explained by the factorial solution being of 59% and having eingvalues above 1. Initially 8 factors were identified. After the sequential removal of all items which presented low saturations during Principal Component Analysis, the final scale ended with 11 items. Table 1 and Table 2 present obtained values at the time that the final scale was defined. Two final factors were retained – *Indignation towards Marine Litter*, including items which are related with cognitive assumptions against the existence of marine litter, as well as with affective assumptions that are related with a dislike towards the existence of marine litter; *Pro-Environmental Behavior Habits*, including items which are related with pro-enviromental behaviors, such as recycling or buying environmental-friendly products. These two final factors explained 28% of total variance.

After the factor analysis, reliability was calculated for the final attitudinal scale towards marine litter, which consisted of a total of 11 items. The Cronbach's alfa (α) relative to the internal consistency of the attitudinal scale was good (α =.82). As for the the Cronbach's alfa of the two final factors, it was also good (α =.84) for the factor one, and acceptable (α =.72) for the factor 2.

Table 1 – Results on internal consistency of the attitudinal scale about Marine Litter.

Item	Cronbach's Alpha	N of Items
Final scale	.82	11
Factor 1 – Indignation towards Marine Litter	.84	7
Factor 2 – Pro-Environmental Behavior Habits	.72	4

Table 2 – Final factors and translated items on the attitudinal scale about Marine Litter.

Items	Factor 1	Factor 2
15. The suffering of marine animals due to entanglement and ingestion of plastics disturbs me.	.74	
19. The dead or suffering of animals due to marine litter is something that should NOT happen.	.73	
21. I think we should act againgst the increment of marine litter in our planet.	.72	
20. I am worried that the incrementing production of plastics and the incrementing human population will cause marine litter to get worse.	.70	
18. I would like my favorite beaches and rivers NOT to be polluted in the future.	.68	
31. I think that the marine litter case is relevant for our current society.	.68	
2. I think that the amount of garbage currently present on the oceans is an important subject.	.60	

11. I try to inform myself about the composition and characteristics of the materials used on the products that I buy everyday.	.79
26. I try to inform myself about what I can do to reduce my contribution to environmental pollution.	.76
24. I try to use productsthat are less harmful for the environment.	.75
10. I try to reutilize and/or recycle the plastic that I use on my everyday life.	.60

Extraction Method: Principal Component Analysis.

Rotation Method: Varimax with Kaiser Normalization.[a]

a. Rotation converged in 3 iterations.

2.2.1.1 Participants' Attitudes towards Marine Litter

Mean responses for factor one (*Indignation towards Marine Litter*) were very high ($M = 6.5$; $SD = 0.7$), that is, between "Agree" and "Strongly Agree". For factor two (*Pro-Environmental Behavior Habits*), mean response was 4.93 ($SD = 1.10$), that is, "Partially agree".

2.2.2 Scale towards Infographics

Factor analysis revealed that the sampling was adequate, as the Kaiser-Meyer-Olkin Measure of Sampling Adequacy was of .930, $p < .001$. Bartlett's test of sphericity was significant ($\chi 2\ (406) = 5020.23$, $p < .05$). Factor analysis began with all items of the scale, with total variance explained by the factorial solution being of 71% and having eingvalues above 1. Initially 5 factors were identified. After the sequential removal of all items which presented low saturations during Principal Component Analysis, the final scale ended with 20 items. Table 3 and Table 4 present obtained values at the time that the final scale was defined. Three final factors were retained – *Importance and Advantages of Infographics*, including items which are related with cognitive assumptions in favor of the importance and of the advantages of infographics for communication; *Infographics Reading Habits*, including items which are related with behaviors related with the habitual reading of infographics; *Liking of Infographics Reading* – with items related with affective assumptions towards the reading of infographics. These three final factors explained 62% of total variance.

After the factor analysis, reliability was calculated for the final attitudinal scale towards infographics, which consisted of a total of 20 items. The Cronbach's alfa (α) relative to the internal consistency of the attitudinal scale was excellent (α =.95). As for the the Cronbach's alfa of the three final factors, it was also excellent (α =.96) for the factor one, good (α =.89) for the factor 2 and good also for the factor three (α =.81).

Table 3 – Internal consistency of the attitudinal scale about Infographics.

Item	Cronbach's Alpha	N of Items
Final scale	.95	20
Factor 1 – Importance and Advantages of Infographics	.96	11
Factor 2 – Infographics Reading Habits	.89	5
Factor 3 – Liking of Infographics Reading	.81	4

Table 4 – Final factors and translated items of the attitudinal scale about Infographics.

Items	Factor 1	Factor 2	Factor 3
8. I think that it is important to know how to read and to interpret efficiently information transmitted via infographics.	.80		
9. I think that infographics add communicative quality when they accompany texto.	.84		
10. I think that infographics should be more used to communicate information.	.84		
13. I think that infographics are a mean of communication very visually appealing.	.76		
16. I think that infographics are useful to transmit information in a synthetised way.	.83		
17. I think that it is important that the media start using more infographics to better communicate with their audience.	.82		
18. I think that it is important that the scientific community starts to use more infographics to better communicate with their audience.	.84		
21. I think that infographics can facilitate the comprehension of complex and abstract topics, like some scientific topics.	.88		
26. I think that it is important to develop the hability to read infographics on students.	.76		
28. When I see an infographic, I feel tempted to read it.	.69		
29. I think that infographics allow for an easier and more perceptible consumption of information.	.84		
1. I am familiarized with infographics.		.64	
2. I try to read infographics related with my studies and/or personal interests.		.79	

3. On my daily life I like to read information via infographics.	.82	
4. I try to look for infographics related with my studies.	.84	
6. I usually read infographics.	.79	
7. Infographics are NOT an efficient method to communicate information to readers.		.76
14. When I see infographics, online or printed, I avoid reading them.		.81
27. I do NOT like to find increasingly more infographics on the information that I read online.		.75
20. I do NOT like to read infographics.		.81

Extraction Method: Principal Component Analysis.

Rotation Method: Varimax with Kaiser Normalization.[a]

a. Rotation converged in 5 iterations.

2.2.2.1 Participants' Attitudes towards Infographics

Results are presented in Table 5. These were divided by group of participants – first, attitudes of all respondents are presented. Secondly, attittudes of only the participants who referred to know what an infographic was are presented. Also, results are presented by dimensions of factors identified during factor analysis (*Importance and Advantages of Infographics*, *Infographics Reading Habits* and *Liking of Infographics Reading*). Mean responses for factor one within all respondents demonstrated a neutral, slightly favourable ($M = 4.90$; $SD = 1.40$) – "Partially agree" attitude towards the *Importance and Advantages of Infographics*. As for the second factor, on infographics reading habits, mean answer was 3.42 ($SD = 1.65$), that is "Partially disagree", while most frequent answer was 1 ("Strongly disagree"). Factor 3, on "Liking of Reading Infographics", showed a more favourable mean of 5.34 ($SD = 1.65$), that is, mean response was "Partially agree"; most frequent responses, however, tied on either "Strongly agree" and "Neither agree nor disagree".

Of all participants ($n = 313$), only 229 (73%) answered the scale on attitudes towards infographics; most certainly the remaining 84 (27%) didn't answer because they didn't know what an infographic was. Additionally, 66 (29%) participants affirmed not to know what an infographic was, totalizing 150 (48%) participants who didn't know what an infographic was or that didn't answer. That said, an analysis of attitudes only within the group of participants who knew what an infographic was was also carried out ($n = 163$). Dimension *Importance and Advantages of Infographics* revealed a mean response of 5.42 ($SD = 1.12$), that is, "Partly Agree". As for dimension *Infographics Reading Habits*, mean response was 4.08 ($SD = 1.40$), that is, "Neither agree nor disagree". As for dimension *Liking of Infographics Reading*, mean response was 5.52 ($SD = 1.22$), that is, between "Partially agree" and "Agree".

Table 5 – Means and standard deviations obtained for all indicators, for all respondents and for only those which knew what infographics were.

	Importance and Advantages of Infographics	Infographic Reading Habits	Liking of Infographics Reading
All respondents (n = 229)	4.90 *(1.40)*	3.42 *(1.65)*	5.34 *(1.65)*
With knowledge of infographics (n = 163)	5.42 *(1.12)*	4.08 *(1.40)*	5.52 *(1.22)*

2.2.3 Social Representations

For this part of the study, data of 259 participants was analysed. The data of the remaining 54 participants was not used for this study, as either they participated in the second empirical study as well (50), and therefore had a different condition of social representations analysis, or they didn't answer to this part of the questionnaire (4). Results will be described by each word/stimulus investigated in the following order – "marine litter", "plastics", "environment/nature" and, finally, "infographics".

2.2.3.1 Marine Litter

A total of 1219 terms were analysed, and after the removal of single terms, 1170 terms were allocated within 32 categories of similar terms (Table 6). Both before and after HI presented low values, indicative of a consensus in the terms referred by participants. Although the after HI assumed less than half of the value of the before HI, this difference should be read considering the low value of both indexes. The number of total occurrences (1170), when taking account of the number of participants (259), indicates that there were 4.52 occurrences per participant, therefore meaning that participants in general could think of 4 or more words or sentences when they thought of "marine litter".

Table 6 – Results on total occurrences, different occurrences and HI for the representation of marine litter.

	Moment	Occurrences	Different occurrences	HI
Marine Litter	Before	1219	81	.07
	After	1170	32	.03

Mentioned terms or expressions, their frequency and mean positions (1 – most important to 5 – least important) on the word/stimulus "marine litter" are listed in Table 7.

Table 7 – Terms, total occurrences, occurrence frequencies and mean positions obtained for the representation of marine litter.

	Occurrences	Occurrence frequency	Mean position
Pollution	179	.15	2.6
Death	145	.12	2.5
Plastics	145	.12	3.1
Marine species	97	.08	3.4
Petroleum	88	.08	3.1
Garbage	50	.04	3.0
Marine environment	45	.04	3.0
Human irresponsibility	44	.04	2.8
Danger	42	.04	2.4
Extinction	35	.03	2.1
Fishing	32	.03	3.2
Concern	30	.03	3.3
Bottles	25	.02	2.9
Animals suffering	21	.02	2.4
Disturbance of Nature	19	.02	2.8
Capitalism	17	.01	3.5
Cigarrete butts	17	.01	3.7
Humans	16	.01	2.4
Garbage patchs	15	.01	2.4
Cans	15	.01	3.8
Must be fought	13	.01	1.6
Litter ingestion	12	.01	3.4
Environment	10	.01	3.3
Diseases	10	.01	3.5
Problem	9	.01	3.4
Waste	7	.01	3.6
Microplastics	7	.01	3.6
Glass	6	.01	4.0

Terms depicted comprise 98% of all mentioned terms. Other 2% included terms related with "excess" (5 mentions), "cotton buds" (5 mentions), "chemicals" (5 mentions) and "mutations" (4 mentions). Top ten mentioned terms comprise 74% of all occurrences. This illustrates the

homogeneity of the representation, as in just one third of the categories that occurred, we find almost three quarters of all occurrences. Also, the top five most frequent terms alone compress more than half of all occurrences (55%). Mean positions of importance for all mentioned terms showed considerable variation (1.6 – 4). Within the ten most frequent terms, this variation was smaller (2.1 – 3.4).

Table 8 presents the ten most frequent terms (74% of all occurrences) combined with their medium importance, in order to infer about the more central or peripherial role of such terms in the representation of marine litter within our social group. Within the most frequent terms, the only one that was both more frequent and classified as more important was "death". Terms that were classified as important but that were less frequent included "danger" and "extinction". Terms that were frequent but classified as less important included "pollution", "plastics", "marine species" and "petroleum". Both less frequent and less important elements indicated were "garbage", "marine environment", and "human irresponsibility".

Table 8 – Central (more frequent and more important) and peripheral (frequent but less important) elements for the representation of marine litter.

		Rank of importance	
		High (≤2.5)	Low (>2.5)
Frequency	High (>.05)	*Death*	*Pollution* *Plastics* *Marine species* *Petroleum*
	Low (<.05)	*Danger* *Extinction*	*Garbage* *Marine environment* *Human irresponsibility*

2.2.3.2 Plastics

A total of 1223 terms were analysed, and after the removal of single terms, 1174 terms were allocated within 32 categories of similar terms (Table 9). Both before and after HI presented low values, indicative of a consensus in the terms referred by participants. Although the after HI assumed less than half of the value of the before HI, this difference should be read considering the low value of both indexes. The number of total occurrences (1174), when taking account of the number of participants (n = 259), indicates that there is a total of 4.53 occurrences per participant, therefore meaning that participants in general could think of 4 or more words or sentences when they thought of "plastics".

Table 9 – Results on total occurrences, different occurrences and HI for the representation of plastics.

	Moment	Occurrences	Different occurrences	HI
Plastics	Before	1223	81	.07
	After	1174	32	.03

Mentioned terms, their frequency and mean positions (1 – most important to 5 – least important) on the word/stimulus "plastics" are listed in Table 10. Terms depicted comprise 99% of all mentioned terms. Other 1% included terms related with "human irresponsability" (5 mentions), "garbage patches" (5 mentions), "artificial" (4 mentions), "microplastics" (4 mentions), "fragile" (4 mentions), "cans" (4 mentions) and "diseases" (4 mentions). Top eleven mentioned terms comprise 81% of all occurrences. This also illustrates the homogeneity of the representation, as in just one third of the categories that occurred, we find more than four-fifths of all occurrences. Also, the top five most frequent terms alone compress more than half of all occurrences (52%).

Mean positions of importance for all mentioned terms showed considerable variation (1.9 – 4), which was the same range of variation within the eleven most frequent terms. Table 11 presents the eleven most frequent terms (81% of all occurrences) combined with their mean importance, in order to infer about the more central or peripherial role of such terms in the representation of plastics within our social group.

Within the most frequent terms, the only one that was both more frequent and classified as more important was "pollution". Also, the only term that was classified as important but that was less frequent, therefore contrasting with "pollution", was "death and suffering of animals". Terms that were frequent but classified as less important included "garbage", various plastic objects ("bottles", "packaging", "bags" and "other plastic objects") and "recycling". Both less frequent and less important elements indicated were "disposable", "marine environment", and "petroleum".

Table 10 – Terms, total occurrences, occurrence frequencies and mean positions obtained for the representation of plastics.

	Occurrences	Occurrence frequency	Mean position
Pollution	146	.12	1.9
Garbage	126	.11	2.7
Bottles	145	.10	3.2
Recycling	115	.10	2.7
Packaging	101	.09	3.3
Bags	94	.08	3.2
Other plastic objects Straws (20), Cups (13), Lids (13), Toys (9), Pens (9)	93	.08	4.0
Disposable	50	.04	3.0
Marine environment	33	.03	3.2
Death and suffering of animals	31	.03	2.2
Petroleum	31	.03	2.8
Slow degradation	27	.02	2.9
Disturbance of Nature	26	.02	2.4
Capitalism	25	.02	3.4
Excessive production	24	.02	2.4
Food	16	.01	3.5
Danger	13	.01	2.4
Useful	13	.01	3.0
Bio and not bio-degradable	13	.01	3.4
Environment	12	.01	2.7
Chemicals	10	.01	2.9
Cheap	9	.01	2.7
Everywhere	9	.01	4.0
Animals	6	.01	3.2
Development	6	.01	4.0

Table 11 – Central (more frequent and more important) and peripheral (frequent but less important) elements for the representation of plastics.

		Rank of importance	
		High (≤2.5)	Low (>2.5)
Frequency	High (>.05)	*Pollution*	*Garbage* *Bottles* *Recycling* *Packaging* *Bags* *Other plastic objects*
	Low (<.05)	*Death and suffering of animals*	*Disposable* *Marine environment* *Petroleum*

2.2.3.3 Environment/Nature

A total of 1297 terms were analysed, and after the removal of single terms, 1269 terms were allocated within 34 categories of similar terms (Table 12). Both before and after HI presented low values, indicative of a consensus in the terms referred by participants. Although the after HI assumed almost half of the value of the before HI, this difference should be read considering the low value of both indexes. The number of total occurrences (1269), when taking account of the number of participants (259), indicates that there is a total of 4.89 occurrences per participant, therefore meaning that participants in general could think of all 5 requested words or sentences when they thought of "environment/nature".

Table 12 – Results on total occurrences, different occurrences and HI for the representation of environment/nature.

	Moment	Occurrences	Different occurrences	HI
Environment/Nature	Before	1297	62	.05
	After	1269	34	.03

Mentioned terms, their frequency and mean positions (1 – most important to 5 – least important) on the word/stimulus "environment/nature" are listed in Table 13. Terms depicted comprise 98% of all mentioned terms. Other 2% included terms related with "natural" (6 mentions), "future" (5 mentions), "patrimonium" (4 mentions), "environment" (4 mentions),

"walks" (4 mentions) and "Man" (4 mentions). Top twelve mentioned terms comprise 73% of all occurrences. This also illustrates the homogeneity of the representation, as in less than one third of the categories that occurred, we find almost three quarters of all occurrences. Also, the six most frequent terms alone compress exactly half of all occurrences (50%). However, this homogeneity was inferior to that of previous words/stimulus.

Mean positions of importance for all mentioned terms showed considerable variation (2.1 – 4.3); within the twelve most frequent terms this variation was smaller (2.1 – 3.5).

Table 14 presents the twelve most frequent terms (73% of all occurrences) combined with their medium importance, in order to infer about the more central or peripherial role of such terms in the representation of environment/nature within our social group. Within the most frequent terms, two emerged as both more frequent and classified as more important – "life" and "clean air". The only term that was also classified as important but that was less frequent, therefore contrasting with "life" and "clean air", was "preservation". Terms that were frequent but classified as less important included "green spaces", "fauna", "trees" and "flora". Both less frequent and less important elements were variated and included "aquatic environments", "pollution", "peace", "disturbances of nature" and "sea".

Table 13 – Terms, total occurrences, occurrence frequencies and mean positions obtained for the representation of environment/nature.

	Occurrences	Occurrence frequency	Mean position
Green spaces Green (68), Forests (41), Fields (11), Green spaces (10)	173	.14	3.2
Fauna	143	.11	3.0
Trees	94	.07	3.3
Flora	80	.06	3.5
Clean air	78	.06	2.5
Life	72	.06	2.1
Aquatic environments	69	.05	3.5
Pollution	56	.04	3.4
Preservation	55	.04	2.4
Peace	55	.04	3.4
Disturbances of Nature	40	.03	2.6
Sea	38	.03	3.3
Sustainability	27	.02	2.7
Ecology	26	.02	2.4
Happiness	23	.02	3.4
Beauty	22	.02	3.7
Purity	21	.02	3.5
Landscape	21	.02	3.5
Essential	20	.02	2.2
Planet Earth	20	.02	2.9
Man's Influence	20	.02	3.2
Sky	19	.01	3.4
Habitat	19	.01	3.7
Climate	13	.01	3.6
Resources	12	.01	4.3
Health	10	.01	3.0
Liberty	9	.01	2.4
Natural disasters	7	.01	3.8

Table 14 – Central (more frequent and more important) and peripheral (frequent but less important) elements for the representation of environment/nature.

		Rank of importance	
		High (≤2.5)	Low (>2.5)
Frequency	High (>.05)	*Life* *Clean air*	*Green spaces* *Fauna* *Trees* *Flora*
	Low (≤.05)	*Preservation*	*Aquatic environments* *Pollution* *Peace* *Disturbances of Nature* *Sea*

2.2.3.4 Infographics

First, we will present results regarding the lack of knowledge that was verified within participants about infographics. Later, we present results on infographics representations within participants who responded to the questionnaires.

2.2.3.5 What is an *Infographic*?

Many participants did not mention any terms related with infographics, later revealing or writing in the questionnaire that "*I don't know what an infographic is, so I didn't asnwer"*. A total of 165 participants, in all 313, either affirmed that they didn't know what an infographic was or didn't answer (53%). However, some participants that didn't know what an infographic were still answered the questions regarding the representations on infographics ($n = 4$). All respondents (n = 152, corresponding to 49%) were considered for the analysis of the representations on infographics.

2.2.3.6 Representations on Infographics

A total of 654 terms were analysed, and after the removal of single terms, 628 terms were allocated within 23 categories of similar terms (Table 15). Both before and after HI presented low values, indicative of a consensus in the terms referred by participants. Although the after HI

assumed almost half of the value of the before HI, this difference should be read considering the low value of both indexes. The number of total occurrences (628), when taking account of the number of participants (152), indicates that there is a total of 4.13 occurrences per participant, therefore meaning that participants in general could think of 4 words or sentences when they thought of "infographics".

Table 15 – Results on total occurrences, different occurrences and HI for the representation of infographics.

	Moment	Occurrences	Different occurrences	HI
Infographics	Before	654	49	.07
	After	628	23	.04

Mentioned terms, their frequency and mean positions (1 – most important to 5 – least important) on the word/stimulus "environment/nature" are listed in Table 16. Terms depicted comprise all mentioned terms. Top ten mentioned terms comprise 75% of all occurrences. This also illustrates the homogeneity of the representation, as in two-fifths of the categories that occurred, we find three quarters of all occurrences. Also, the six most frequent terms alone compress more than half of all occurrences (59%).

Mean positions of importance for all mentioned terms showed a bigger variation (2 – 5.3), which was not verified for other words/stimulus, which was due to the fact that there were more answers for this word/stimulus, and in some cases, participants would give more than the requested 5 answers, and then rate the importance of each answer with more than 5. However, within the ten most frequent terms this variation was much smaller (2 – 3.2).

Table 17 presents the ten most frequent terms (75% of all occurrences) combined with their medium importance, in order to infer about the more central or peripherial role of such terms in the representation of infographics within our social group.

Table 16 – Terms, total occurrences, occurrence frequencies and mean positions obtained for the representation of infographics.

	Occurrences	Occurrence frequency	Mean position
Imagetics	98	.16	2.9
Information	84	.13	2.0
Graphics	79	.13	3.0
Dissemination	46	.07	2.7
Teaching	33	.05	2.9
Statistics	29	.05	3.2
Analysis	25	.04	3.0
Maps	24	.04	2.6
Synthesis	22	.04	3.0
Understanding	22	.04	2.9
Data	21	.03	2.6
Text	19	.03	3.2
Useful	18	.03	3.3
Asthetics	16	.03	3.3
Science	16	.03	3.7
Color	15	.02	3.2
ICT	15	.02	3.8
Simplicity	14	.02	2.9
Knowledge	8	.01	2.7
Accessible	8	.01	3.3
Journalism	6	.01	4.0
Interactivity	5	.01	3.7
Paper	5	.01	5.3

Within the most frequent terms, only one emerged as both most frequent and most important – "information". No contrasting term with this central one was found. Terms that were frequent but classified as less important included "imagetics", "graphics", and "dissemination". Both less frequent and less important elements were variated and included "teaching", "statistics", "analysis", "maps", "synthesis" and "understanding".

Table 17 – Central (more frequent and more important) and peripheral (frequent but less important) elements for the representation of infographics.

		Rank of importance	
		High (≤2.5)	Low (>2.5)
Frequency	High (>.05)	*Information*	*Imagetics* *Graphics* *Dissemination*
	Low (≤.05)	-	*Teaching* *Statistics* *Analysis* *Maps* *Synthesis* *Understanding*

2.3 Discussion

We will begin this section with a discussion of the results on the attitudes of participants and on the attitudinal scales, later moving to the discussion of the results on social representations that were gathered from participants.

2.3.1 Attitudes

In the case of the attitudinal scale towards infographics, it was verified that the three final factors identified by factor analysis can be associated with the original intended factors for this scale (ABC model) (Rosenberg & Hovland, 1960) – Affective (*Liking of Reading Infographics*), Behavioral (*Infographics Reading Habit*) and Cognitive (*Importance and Advantages of Infographics*). Internal consistency for the final scale on infographics was excellent.

As for the attitudinal scale towards marine litter, such was not verified, with the only two factors identified (*Indignation towards Marine Litter* and *Pro-Enviromental Behavior Habits*) consisting of one factor that somewhat mixes the affective and cognitive components of attitudes, and the second factor being clearly one that relates with the behavioral component of attitudes towards marine litter. Internal consistency of the final scale on marine litter was good.

Such results, although not always identifying the three components in the analysed data, nevertheless confirm that the ABC model for attitudes is suited for studying and understanding

the building of individual's attitudes towards social objects. In fact, this junction of components is a frequent result of works which intend to develop scales based on these three components of attitudes as indicated by Rosenberg & Hovland's (1960) (Lima, 2004).

2.3.1.1 On the Environmental Case of Marine Litter

Attitudes of participants towards marine litter showed that while they are strongly agreeing that there is in fact a problem and that such problem should be addressed (*Indignation towards marine litter* with mean answer of "Agree", and with a big portion of answers' frequencies on the strong positive side of answers), when we look at the indicator of "*Pro-Environmental Behavior Habits*", with mean answer of "Partially agree", we can understand that while this group is concerned with the topic of marine litter and its consequences, their actions are not agreeing with their ideias. Such goes in line with reviewed literature, as it has been stated before that "effective motivation of audiences to adopt environmental-friendly behaviors is challenging" (Lazard & Atkinson, 2015), and also, that by just evaluating individuals' environmental concern it does not mean that we are evaluating their behaviors on the preservation of the environment (Castro, 2005).

The positive tendency of results towards a concern regarding the environmental problem of marine litter, however, agrees with the notion that, currently, society is leaving obsolete, self-interested, ego-centered views and adopting more conscious, eco-centered views, not only on the environment but also on economic and social levels (Scharmer & Kaeufer, 2013). This view goes in line with the vision described as the New Ecological Paradigm, which has been being described as more common since the 1970s, operated by a growing of conscience about the end of humanities' "era of exuberance" and the new "era of scarcity" within a global ecosystem that is finite and with ecological laws to which humans cannot escape (Castro, 2005; Dunlap & Van Liere, 1978).

2.3.1.2 On Infographics

For all respondents, the mean response for this indicator being "Partially agree" goes in line with the results for the next dimension (*Infographic Reading Habits*, mean answer of "Partially disagree"), as that demonstrates that a big portion of respondents have very little experience and habits of reading infographics, therefore not being able to conclude on a stronger position on the importance or advantages of this communication format. Also, on *Liking of Reading Infographics*, responses were somewhat neutral, with a slight positive tendency (M = 5.34; SD = 1.65, corresponding to "Partially agree").

A total of 150 participants (48%) didn't answer to the attitudinal scale on infographics, while 165 participants (53%) affirmed that they didn't know the meaning of infographic. Such results

confirm the lack of experience and, therefore, of either positive or negative formed attitudes towards infographics.

Results focused only on participants who knew what an infographic was revealed slightly more positive attitudes towards infographics - *Importance and Advantages of Infographics* with mean response of 5.42 (*SD* 1.12), "Partially Agree"; *Liking of Infographics Reading* with mean response 5.52 (*SD* 1.20), between "Partially agree" and "Agree". But in this case as well low habits of reading infographics were revealed, as the indicator *Infographics Reading Habits* obtained a mean answer of 4 ($M = 4.08$, $SD = 1.40$), that is, "Neither agree nor disagree".

These results contradict the popularity of this format that has been referred earlier (Dunlap & Lowenthal, 2016), at least amongst our participants, where the experience with this format could be expected higher. In fact, in the Faculty of Arts there are courses specifically dedicated to the communication sciences, to journalism – where the usage of this format has been increasing, although slowly and very far from the one verified for Spain, for instance (Cardoso, 2010) – and, also, there are curricular units entirely or partially dedicated to the study of infographics and even a whole service in this faculty dedicated specifically to infographic development.

2.3.2 Social Representations

We will discuss each set of results according to each word/stimulus applied. First, we will discuss the results on "marine litter"; then on "plastics", on "environment/nature", and, finally, on "infographics".

2.3.2.1 Marine litter

A low value of HI, both before and after the creation of the final categories of terms, indicated consensus in the terms referred by participants, regarding the word/stimulus "marine litter", which was confirmed by the fact that within the ten most frequent terms mentioned were almost three quarters (74%) of all occurrences.

Participants in general could think of 4 or more words or sentences when they thought of "marine litter", which, added to the fact that all participants could mention words or sentences related with the term, indicates that its social representation is already formed or in formation in our group of participants. This conclusion goes in line with predicted outcomes, as the topic of marine litter has recently been frequently reported in the news ("*Heartbreaking Photos Show What Your Trash Does to Animals*", 2017; Albeck-Ripka, 2018).

From the organization of Table 8, we understand that the social representation of "marine litter", on our group of participants, is being centered around the term "death", the only one being both more frequent and classified as more important. The terms "danger" and "extinction" are elements that appear on a smaller number of participants, but they consider them as central to "marine litter", that is, these are constrasting central elements of the representation of marine

litter. While all of these terms ("death", "danger" and "extinction") are related with the bad consequences of marine litter for the environment, they also denote some apparent confusion on participants in relation with the real consequences of marine litter - while some think that it kills, other think that it is something dangerous or that causes extinction on some species. "Extinction", however, is not currently directly associated with marine litter (Andrady, 2011; Ivar do Sul & Costa, 2014; Cózar *et al*., 2014; Wagner *et al*., 2014; Geyer *et al*., 2017); nevertheless, participants seem to be thinking so. This might also be happening due to the nature of the media depictions of marine litter consequences for animal life, focusing strongly on pictures of birds and other marine species either found dead or entangled, and with their opened guts full of plastic objects (Ruiz-Grossman & Dahlen, 2017; Zachos, 2018).

As for the peripheral elements of the representation of marine litter within participants, first peripheral elements (more frequent and less important mentions) found were "pollution", "plastics", "marine species" and "petroleum". These elements are adding heterogeneity and individual divergence to the representation (Abric, 1994; Vala & Monteiro, 2004), while protecting the central core of "death". "Pollution" is a term that can easily be associated with marine litter, as the very word "litter" implies. As for "plastics", this is a more interesting result, as it tells us that participants are associating marine litter with plastic, the most frequent component of marine litter (Galgani *et al*., 2015; UNEP & GRID-Arendal, 2016) – although only some individuals of the social group are making such association, as this is a peripheral element. "Marine species", when associated with the central "death", indicates that participants are focusing on the consequences of marine litter for the marine species only, and not for all the species that can be affected by this litter, that is, for instance, all the intervenients of the maritime food chain, including humans (Andrady, 2011; Ivar do Sul & Costa, 2014; Cózar *et al*., 2014; Wagner *et al*., 2014; Geyer *et al*., 2017). "Petroleum" is a term that can be either being associated by our participants with the origin of plastics or with prior and frequent news on maritime pollution due to oil spills on the open sea, the last and larger one having happened on April 2010, which is also a kind of situation where many marine species are visually affected and where the pollution of the oceans is more visible (U.S. National Oceanic and Atmospheric Administration, 2018). Finally, as second periphery elements of the representation of marine litter, that is, as less frequent and less important elements, we have terms such as "garbage", "marine environment" and "human irresponsibility". Again, with these first two terms, there is a repetition of terms related with marine litter and pollution; as for the linkage of human activity with marine litter, it is clear that such is not being strongly represented in our participants.

More scientifically specific occurrences, like "microplastics" or "litter ingestion" were present but very scarcely mentioned (7 and 12 mentions, respectively), as well as terms related with "health" ("diseases" with 10 mentions), which might indicate that this group of respondents is not familiar at a deeper level with the scientific aspects and full consequences of marine litter. Overall small variation on the mean of importances for all terms also indicates that the representation on marine litter is still not fully consolidated, as participants weren't able to

strongly identify central aspects of the representation besides "death", an even this term was rated with an intermediate mean importance (2.5).

Nevertheless, it was verified that the elements with lower mean position (ranked more important) were related with the environmental consequences of marine litter, whereas in the higher positions (ranked less important) we can find elements related with the causes of marine litter, such as plastic and petroleum consumption or human mismanagement. It becomes clear that the topic is, however, not affecting emotionally our participants in a relevant way, as "concern" exhibits very little frequency (30 mentions, 3%) and low importance (3), and no others affective terms are amongst the most frequent occurrences. We should note, for example, the absence of explicit concerns about the impacts of marine litter on human health, or about individual habits of consumption. Overall, we can perceive how this social group is looking at at the marine litter problem as a situation not related with humans, but instead as some kind of "*mortal/dangerous kind of pollution related with plastics and/or to petroleum that is affecting marine species*".

2.3.2.2 Plastics

Low values on before and after HI were indicative of a consensus in the terms referred by participants, which was confirmed by the fact in just eleven (one third) of all categories of terms were four-fifths (81%) of all occurrences. This percentage was greater than the one verified for marine litter, and such is not surprising, as plastics are expected to be more familiar to participants than marine litter.

There were 4.53 occurrences per participant, which means that participants in general could think of 4 or more words or sentences when they thought of "plastics", and, therefore, that the term is familiar within the social group – that is, that the social representation is already present. Also, the means of importances given to terms (between 1.9 and 4) presented considerable variation, which means that participants do seem to have a structured representation of plastics present (Abric, 1994; Vala & Monteiro, 2004), which is expected to happen, since it is a well know term and very present material in our daily lives (Geyer *et al*., 2017).

Nevertheless, the term "pollution" stood out as the only both most frequent and more important – that is, as a central - element of the representation of "plastics" within the social group. Contrasting with this term was "death and suffering of animals", as it was a less frequent but also considered important term of the representation, therefore being present in a minority of partipants as central to this representation (Monaco *et al*., 2016); this contrasting element might be present in a group of participants that is associating more strongly plastics with marine litter and its consequences for marine life, that is, more recent views on the consequences of plastics for the environment. In fact, as seen in the representation of marine litter, some participants, but not all (as it came as a peripheral element), were already associating marine litter with plastics, together with "death" – so the inverse reaction is not surprising. Also, in this case, the media

depiction of animals trapped on plastic objects and full of plastics inside them must have had a contribution to this representation (Ruiz-Grossman & Dahlen, 2017; Zachos, 2018).

Other most frequent terms but classified as less important were "garbage", various plastic objects ("bottles", "packaging", "bags" and "other plastic objects") and "recycling". Both "garbage" and "recycling" denote a repetition of terms related with the central element "pollution", but also goes in line with literature that points plastic as the most commonly used and disposed material of our current lives (Cózar *et al*., 2014; Wagner *et al*., 2014; Geyer *et al*., 2017). Also, the mention of a wide range of common objects that are made of plastic goes in line with such notion, indicating that participants are mentally conscious of the ubiquity of plastic in todays' world. The fact that "everywhere" was also a term mentioned by participants (9 mentions) in relation with plastics also confirms this view. The mention of "recycling" was quite common in participants (115 mentions, 10%); however, literature tells us that only 9% of ever produced plastic waste was recycled until today (Geyer *et al*., 2017), and in Portugal, data of 2014 revealed that only 30.4% of all waste was being recycled (PORDATA, 2018), so this might be a point that future communication related with plastics needs to pay attention to, by letting readers know that, in spite of their frequent association of plastics with "recycling", this association is not being fully put into practice, and it should, in order to reduce plastics long-lasting presence in our environment.

As second peripherial elements of the social representation of plastics amongst participants, terms like "disposable", "marine environment", and "petroleum" emerged. These terms come up as being nor very important nor frequent in this social representation of plastics, within the studied social group. In fact, plastic objects have been already described as being characterized by an "intense consumption, *rapid disposal* and inappropriate management after usage" (Cózar *et al*., 2014, pp 1), which has actually been leading for years to an extensive accumulation of plastics in the environment, particularly in the marine environment (Geyer *et al*., 2017; Wagner *et al*., 2014) – so the terms "disposable" and "marine environment" are in line with the state of the art in plastics fate on the environment. Although they were referred by few participants, there were some participants that seemed to be aware of plastics' contribution to marine litter and global pollution. As for the term "petroleum", this is a term that has also appeared related with marine litter, and a doubt had arise for whether this mention of "petroleum" was related with oil spills that polluted the oceans, as a "source of marine litter", or with plastics origins; this less frequency and importance of "petroleum" on the representation of plastics seems to indicate that participants generally do not associate plastics with "petroleum"; however, there were some mentions of it (31.3%), so the association "petroleum-plastics" seems to be weak, but somewhat present; as for the association "petroleum-plastics-marine litter", it does not seems so plausible, but results remain inconclusive on that aspect.

Other important terms, according with recent scientific knowledge, could have been more salient, particularly those related with the contribution of plastics to marine litter and global pollution – such as "microplastics" (4 mentions) or those related with plastics' properties that

make this material such a versatible but problematic one, like their ability to affect health by concentrating pollutants or by ingestion (4 mentions for "diseases", no mentions of "ingestion") or their long degration times (27 mentions, 2%) (Andrady, 2011; Browne, 2015; Galgani *et al*., 2015; Ivar do Sul & Costa, 2014). These mentions were present, but with very low frequencies, which indicates a lesser knowledge of the threat that plastics represent for the environment, within this social group.

Overall, the representation of plastics amongst participants seems to revolve around "*pollution composed of everyday objects*", with some minorities seeing it as "*everyday objects that are killing or injuring animals*".

2.3.2.3 Environment/Nature

A low value of HI was verified both before (*IH* = .05) and after the creation of final categories (.03), which indicated high homogeneity within the terms participants referred. This homogeneity was confirmed by the fact that in just 12 of the most frequent categories (that is, in less than one third of the categories) of terms were almost three quarters of all occurrences (73%).

The total of occurrences per participant (*M* = 4.9) was almost the total of possible answers, which indicates that this was a familiar term for participants, therefore producing more answers, as also the number of total answers (1297) – the highest for all word/stimulus – indicates. Nevertheless, the mean of the importance positions for all terms did not varied a lot (from 2.1 to 4.3 in all categories), which could indicate that, although highly present, the representation of environment/nature is not fully defined on participants.

High familiarity with the term is not surprising, as it has been already stated that, since around the 1970s, environmental questions have been gaining relevance for society, and, therefore, also for other spheres like politics and scientific research, with increasing concerns regarding the nature and severity of environmental deterioration caused by humans (Weigel & Weigel, 1978; Castro, 2005).

Terms "life" and "clean air" emerged as possible central elements of the representation. Constrasting with these terms – considered very important amongst less participants- was the term "preservation". While when we look at "life" we are obtaining a term that is related with a more ecological and biological inclusive view of environment/nature, with "clean air" we are getting a view that is somewhat more related with a human-centered vision of environment/nature, as the mention of the quality of the air is not one related with any other species besides humans themselves, and human health. So, these results seem to denote a conflict of visions towards environment/nature. For one side there is a vision that goes in line with the NEP (New Ecological Paradigm) vision, which looks as nature as full of "life" forms, as at humans as a species among other species, living intertwined in a global ecosystem. For the other side, we get a vision that goes in line with a more anthropocentric vision of environment/nature, not ignoring the biophysical components of environment/nature, but focusing more on their relationship with

humans and with human health that with other species. These results contradict the conclusions of previous works which state that all over the world, people are leaving old anthropocentric views of nature and starting to substitute those with new, more pro-ecological and NEP visions of environment/nature (Castro, 2005; Dunlap & van Liere, 1978). In fact, as Castro & Lima (2001) have concluded in a previous study on the social representations of Portuguese people on environment, it seems that instead of leaving the "old ideas" for these "new ideas", some people are agreeing with both ideas of environment/nature at the same time. As for the emergence of the term "preservation", although not frequent, it shows that some participants within the social group are looking at environment/nature as something that must be cautiously managed and preserved for the future, therefore revealing pro-ecological beliefs on a finite biophysical environment that is being affected and disturbed by humans, which goes in line with the NEP vision.

Possible peripheral elements - that is, elements that are adding individual divergence to the representation - were varied, although somewhat concomitant – "green spaces", "fauna", "trees" and "flora". We can right away join "green spaces" with "trees" and "flora" and realize that this social group is looking at environment/nature as something which is related with the color green and/or with plants; at the same time, we can join "flora" and "fauna" and realize that participants are also looking at environment/nature as something that is biodiverse – which again brings the central ideia of "life", previously mentioned for this representation. Such results are, again, agreeing with a NEP vision of environment. Less frequent and less important elements were "aquatic environments", "pollution", "peace", "disturbances of nature" and "sea". These results are indicative of a frequent non-association of environment/nature with water landscapes, which actually comprise 71% of all of our planet (Howard, 2016). This might also be due to the nature of the landscape found in the city of the study (Porto), which consists of an urban area, with high population density and infrastructure of built environment, nevertheless also having a main river of its own (Douro river). Also, only on these less frequent elements we find terms with a negative connotation – such as "pollution" and "disturbances of nature"; all other terms mentioned so far were positive, and not related with the human influence on environment/nature. As a matter of fact, except for the somewhat more human-related term "clean air", humans do not come up as an element of environment/nature for participants, either positively or negatively. The term "Man" was mentioned, by only four times in all 1297 occurences. These results, again, do not fully go in line with a NEP, all-life-forms-inclusive view on environment, but instead with a view that somewhat opposes "Man" with environment/nature. This is, actually, a point that, being addressed and used on future communication practices related with environmental topics, could add beneficts in terms of added social significance to the message, therefore increasing persuasion levels on participants.

Overall, results seem to indicate that participants are looking at environment/nature as "*vegetal and animal life within a green and clean-aired atmosphere*".

2.3.2.4 Infographics

A total of 165 participants (53%) did not know the meaning of infographic. This result is particularly relevant when one considers that the study was performed in a faculty of Arts, where knowledge of infographics could be thought more common, as several graduation courses of this college teach topics of communication and information sciences, and there is in fact a whole service in this college dedicated specifically to infographic development. This lack of knowledge of infographics contradicts their increasing popularity both online, on media and for teaching purposes (Lazard & Atkinson, 2015; Dunlap & Lowenthal, 2016; Teixeira, *et al*., 2017).

Within the participants that knew what infographics were, however, values of HI were low, therefore indicating consensus within all responses. The fact that within only two-fifths of the categories were comprised three quarters of all responses also confirms the homogeneity of these responses.

A total of 4.13 occurrences per participant was verified, the smaller value for all words/stimulus. This might also be a confirmation of the small familiarity with the term, as it produced less ideas on participants. These results, added to the considerable but small variation on mean importance for all referred terms, and to the lack of familiarity with these tools in more than half of participants, indicate that the representation of infographics is, in fact, in an initial stage of formation within the studied social group.

The only most frequent and most important term was "information", therefore being a candidate for a central element of the representation of infographics. Frequent but less important terms, that is, possible first peripheral elements of the representation, were "imagetics", "graphics", and "dissemination". When one thinks of the definition of infographics – "(…) visual representations of complex data that combine graphics, illustrations, text and static or animated images into a format that tells a complete story" (Krum, 2013, p. 12) – we can identify in such definition the three most frequent referred terms, if we look at "information" as a synonym of "data" or "story", at "imagetics" as a synonym for "representations", "illustrations" and "static or animated images". That said, the representation of infographic, although it is not present in 53% of the participants, in the cases where it is present, it seems that it goes in line with the denotative meaning of infographic; that is, with the literal meaning of the word, as opposed to a connotative, or commonly cultural or emotional association of the word.

Both less frequent and less important elements – second peripheral elements of the representation - were variated and included "teaching", "statistics", "analysis", "maps", "synthesis" and "understanding". Both "statistics" and "analysis" again bring the central notion of "information" or "data", already mentioned for the representation, therefore consisting of repetitive terms. The term "understanding" can also be adjoined either with "dissemination" or with "analysis" of information, indicating that participants seem to be associating infographics with a publicity function. The case of the terms "teaching" and "maps" is in fact a not surprising one, as in the Faculty of Arts several courses rely on infographics that are very rich in map

depictions for teaching purposes – courses such as History or Geography. In fact, the only existing service on this faculty fully dedicated to infographics development is in fact only dedicated to this type of infographics – what Colle (2004) classied as info maps. As for the term "synthesis", this is in fact a precise part of the denotative definition of infographics and of their function as communication tools (Arroyo, 2013; Dunlap & Lowenthal, 2016); the presence of such term also confirms that some participants are aware of what infographics and their functions are, but in a small number (22 mentions).

There was not a connection of infographics with journalism, which indicates that participants are not usually reading news in this format. Previous studies have concluded that in Portuguese journalim this type of communication tool is still on an initial stage of usage, although the first infographic used on a journalistic piece dates as far back as 2001; this is a very different scenario from the one verified in Spain, where infographics are commonly used on journalism (Cardoso, 2010).

Overal, the representation of infographics amongst participants, besides not present in half of them, exhibited tautology of terms related with images and information (Fortunati & Contarello, 2002), which are easily derived of the own word "infographic" (information + graphics); such results therefore confirm the incipiency of the representation. If we were, however, to describe the representation that seems to be taking form on infographics amongst participants, it would be something like "*something that divulgates information in the form of images and/or graphics".*

2.4 Summary and Conclusions

A total of 313 undergraduate Art students were used for the study of their attitudes towards the environmental case of marine litter and of their attitudes towards infographics. Also, their social representations on marine litter, plastics, environment/nature and infographics were gathered and analysed.

New attitudinal scales regarding marine litter and infographics were created and applied; both proved to have good and excellent internal consistencies and revealed indicators such as *Indignation towards Marine Litter* and *Pro-Enviromental Behavior Habits,* for the attitudinal scale on marine litter; and *Importance and Advantages of Infographics*, *Infographics Reading Habit*s and *Liking of Infographics Reading* fot the scale on Infographics.

Attitudes of participants towards marine litter showed that while they are strongly agreeing that there is in fact a problem and that such problem should be addressed (*Indignation towards marine litter* with mean answer of "Agree"), when we look at the indicator of *Pro-Environmental Behavior Habits* (with mean answer of "Partially agree") we can understand that while this group

is concerned with the topic of marine litter and its consequences, their actions are not agreeing with their ideias. The positive tendency of results towards a concern regarding the environmental problem of marine litter, however, agrees with the notion that, currently, society is leaving obsolete, self-interested, ego-centered views and adopting more conscious, eco-centered views (Dunlap & Van Liere, 1978; Castro, 2005; Scharmer & Kaeufer, 2013). Nevertheless, there is some conflict of this result with those from the social representations on marine litter, as they did not strongly express a concern with the topic of marine litter, although it was present in some cases.

Attitudes towards infographics revealed neutral positions towards this multimedia format except on the indicator *Infographic Reading Habits,* with mean answer being "Partially disagree", which explains the two other neutral results (*Importance and advantages of Infographics* and *Liking of Reading Infographics* with the mean response "Partially agree). The lack of experience with infographics was confirmed by the 165 participants (53%) that affirmed that they did not know the meaning of infographic. Moreover, results focused only on participants who knew what an infographic revealed also neutral, slightly more favourable attitudes towards infographics - *Importance and Advantages of Infographics* with mean response of "Partially Agree"; *Liking of Infographics Reading* with mean between "Partially agree" and "Agree", *Infographics Reading Habits* with mean response "Neither agree nor disagree". Results therefore contradict the popularity of this format (Dunlap & Lowenthal, 2016), at least amongst our participants, where the experience with this format could be expected higher, as in their faculty there are courses, curricular units and services specifically dedicated to the communication sciences and to infographics.

The representation of marine litter seems to be in an initial stage of formation within participants, as this was not an unknown term for them. Such goes in line with predicted outcomes, as the topic of marine litter has recently been frequently reported in the news. Their representation is forming around the central term "death", with peripheral elements "pollution", "plastics", "marine species" and "petroleum". The emergence of "plastics" tells us that some participants are already associating marine litter with plastic, the most frequent component of marine litter (Galgani *et al*., 2015; UNEP & GRID-Arendal, 2016) – although only some individuals of the social group are making such association, as this was a peripheral element. However, there was an absence of terms related with the impacts of marine litter on human health, or with habits of consumption, so this social group is still looking at at the marine litter problem as some sort of tragedy that is happening to marine species, and not to humans nor human health. This might be a consequence of the way the topic has been depicted in the news, focusing strongly on pictures of hurt or dead animals with plastics around them or inside them, which means that the communication of the topic needs to start focusing not only on consequences for animals, but also on consequences for humans.

The representation of plastics revealed the central element "pollution". Other most frequent terms but classified as less important were "garbage", various plastic objects ("bottles", "packaging", "bags" and "other plastic objects") and "recycling", which denote a repetition of terms related with the central element "pollution", but also goes in line with literature that points plastic as the most commonly used and disposed material of our current lives (Cózar *et al*., 2014; Wagner *et al*., 2014; Geyer *et al*., 2017). The mention of "recycling" was quite common in participants; however, literature tells us that only 9% of ever produced plastic waste was recycled until today (Geyer *et al*., 2017), so this might be a point that future communication related with plastics needs to pay attention to, by letting readers know that, in spite of their frequent association of plastics with "recycling", this is not being put into practice. Notions more related with plastics contribution to marine litter, like microplastics or plastics ingestion were not very present, therefore revealing lack of more profound knowledge on plastics contribuition to marine litter. Overall, the representation of plastics amongst participants seems to revolve around *"pollution composed of everyday objects".*

The representation on environment/nature revealed the terms "life" and "clean air" as possible central elements, which presents both a bio-inclusive view and a more human-self-centered view on environment/nature. Possible peripheral elements were "green spaces", "fauna", "trees" and "flora". These results reveal that this social group is looking at environment/nature as something which is related with the color green and/or with plants and, at the same time, as something that is biodiverse. Less frequent and less important elements were "aquatic environments", "pollution", "peace", "disturbances of nature" and "sea". These results are indicative of a frequent non-association of environment/nature with water landscapes. Except for the more human-related term "clean air", humans do not come up as an element of environment/nature for participants, either positively or negatively. These results do not fully go in line with a NEP, all-life-forms-inclusive view on environment, but instead with a view that somewhat opposes "Man" with environment/nature, which is a point could be on future communication practices related with environmental topics.

Answers on the representation of infographic were the ones with a smaller number of answers, as the previous referred lack of knowledge with the term had indicated. The term "information" was the only candidate for central element on the representation, while possible peripheral elements were "imagetics", "graphics", and "dissemination". Therefore, also in the participants were the term was known, results reveal a tautology of terms related with images and information, which are easily derived of the own word "infographic" (information + graphics); that confirmed the incipiency of the representation. Nevertheless, most frequent terms revealed concordance with the denotative meaning of infographic. There was not an anchoring (Vala & Monteiro, 2004) of infographics with journalism, which indicates that participants are not usually reading news in this format. Such has been already confirmed on previous studies that revealed a lack of infographics on Portuguese journalism (Cardoso, 2010).

3. Second Empirical Study: Infographic Redesign and Experimental Persuasion Study

Persuasive messages, according to the ELM (Petty & Cacioppo, 1986), are processed by individuals through a continuum of elaboration or significant thinking that varies from low elaboration levels - or little thinking about the message - to higher elaboration levels - or deep thinking about the message (Petty & Cacioppo, 1986; Parker, 2011). Therefore, the level of elaboration on the message that the individuals are reading influentiates the persuasion of such message, by determining one of two possible dominant routes of persuasion – either the central route of processing, or the peripheral route of processing will dominate during the reading of a persuasive message (Parker, 2011, p.7). If the central route of persuasion dominates, careful and thoughtful consideration, attention and scrutiny of the arguments in the message content and thinking about the issue in relation to other issue-relevant knowledge occur, and so the elaboration of the message is considered to be high (Petty & Cacioppo, 1986; Parker, 2011). If, however, the peripheral route of persuasion dominates, that means that the individual processed the message by applying some heuristic to come to a decision about the topic depicted on it – for example, by relying on peripheral cues like source credibility (relying on beliefs about how "right" the communicator may be) or affect (positive or negative feelings the message induces (Petty & Cacioppo, 1986; Parker, 2011) – then the elaboration on the message is considered to have been low. Simply put, as stated by Parker (2011): "(…) the route to how someone is persuaded depends on the extent to which someone processes or thinks about a message" (p. 7).

Also, the dominant route of persuasion during the processing of a persuasive message has proved to affect the attitude change that follows such processing. If the dominant route was the central one, stronger and more enduring attitude changes are verified; if the peripheral route dominates, more volatile and less enduring attitude changes are verified (Petty & Cacioppo, 1986; Parker, 2011).

The role of infographics for the communication of persuasive messages that are related with environmental topics has already been proven effective, as it conducted to higher elaboration levels when compared to text-only media and to more visually abstract media (Lazard & Atkinson, 2015). But can the incorportation of social representations, within a specific social group, increase this effectiveness of communication? In such case, higher levels of engagement and persuasion to pro-environmental and marine litter related communications would result from reading infographics that attend to the representations of the group in regard to such topics, ultimately guiding to stronger and more enduring changes of attitude regarding the environmental topic of marine litter and plastic consumption.

Results from the First Empirical Study on attitudes and representations about marine litter have indicated that within the social group of undergraduate students of Arts from the University of Porto, the theme of marine litter is still in construction, but already being represented around terms like "death", "pollution", "plastics" and "marine species", which indicates a possible personal detachment from this environmental problem, as if it was not related with humans, both in its origin and in its consequences, but only with marine species (Ivar do Sul & Costa, 2014). Also, in the representation of plastics, the representation of it is relating to "pollution", "everyday objects" and "recycling" – among wich is the color "yellow", associated with the plastics container – but in fact recycling of plastics is not being putted into practice, even if it is thought as common. Plastics are, therefore, not being immediately associated with marine litter. As for the views of this social group on environment/nature, previous results have brought the notion of "life" within a "green" scenery and something that appears to be opposed or untouched by humans. Also, aquatic environments seem to be being left out of the environment/nature of this social group.

For this Second Empirical Study, we intended to incorporate and enhance such representations and results in an already existent digital infographic about marine litter, through a whole process of redesign, in order to later create two experimental situations of infographics processing (one for each infographic) and compare results regarding persuasion levels and attitude changing for both experiments, in our participants. As previous results have also made clear the lack of knowledge and usage of infographics amongst our participants, the present work gains relevance by being a way of introducing this multimedia format to new audiences, while presenting results on their influence on persuasion levels of participants.

3.1 Methods

In the following sections the sample used for this study will be descrived, as well as the instruments used and/or adapted to be applied to the experimental situations, and the processes

carried out to their obtainance. Procedures on the creation and realization of the two experimental conditions are also described.

3.1.1 Participants

A total of fifty undergraduated students of Art from the Faculty of Arts of the University of Porto participated in the experimental study, divided in two groups of 25 participants. These participants, while belonging to the same social group as that of study one, consisted of different individuals. Their ages varied between 19 and 53 years (M = 25.57; SD = 9.16). The group consisted of 36% females (n =18) and 64% males (n = 32).

3.1.2 Instruments

Two different digital infographics were used for each group of participants, in order to create two different infographic processing experimental situations. While one group processed the digital infographic, which was developed by the Portuguese team of *Público* newspaper (*Infographic Design One*, Figure 6), the other group processed the digital infographic which was redesigned for this work, using as a basis the one from *Público*, and incorporating in its design results obtained from the empirical study one regarding this social group's representations on "marine litter", "environment/nature", and "plastics" (*Infographic Design Two*, Figure 9). Further sections will explore both infographic designs, as well as the redesign process that was performed, and, finally, the adjusted questionnaire that was used for data gathering on both experimental situations.

3.1.2.1 Original Infographic - *Público*

This digital infographic was developed by science editor Teresa Firmino and infographist Célia Rodrigues, both journalists at the Portuguese newspaper *Público*. Its publication online occurred at February 18th, 2017 (https://www.publico.pt/2017/02/18/infografia/um-oceano-de-plastico-210). The publication, entitled "*Um Oceano de Plástico*" (Figure 6) ["An Ocean of Plastic"], consists of an interactive composition of four pages of infographic material. The composition begins with a brief textual introduction to the theme of plastic pollution on the seas, followed by the authors' names and date of publication, and, finally, the infographic piece itself. A set of four square icons ("*Oceano de Plástico*", "*Degradação do Lixo*", "*Microplásticos*", "*Mar Português*") above each infographic page provides navigation through the piece.

The first page of the infographic – "*Oceano de Plástico*" ["Plastic Ocean"] - describes the navigation of marine litter through the several layers of the ocean, as well as through the marine species that occupy this environment. Additionally, several text-boxes mention top marine litter

producer countries, plastics and microplastics pollution, and entaglement, intoxication, ingestion, and death effects on several animal species.

The second page (Figure 7) – "*Degradação do Lixo*" ["Litter Degradation"] – focus on global production of plastics and its predicted trend for the future, on several plastic objects degradation time, and on the most common plastic litter objects found on beachs around the world, during the year of 2015.

The third page (Figure 7) - "*Microplásticos*" ["Microplastics"] – depicts a global map with the five global ocean gyres and the microplastic concentration all around the world, accompanied by a text box that introduces the concept of "garbage patches".

Finally, the page number four (Figure 8) – "*Mar Português*" ["Portuguese Sea"] - highlights the marine litter that has been reported on the Portuguese coast and waters, as well as some environmental friendly actions that each of us can adopt in order to fight the increment of marine litter globally.

According to the type of infographics that Nichani and Rajamanickam (2003) have described, this infographic is of the instructive type, as it presents content in a sequential fashion, which allows the reader to read explanations step by step, although it also has some characteristics of the explorative type, as it gives readers the possibility to explore and read content that they are left to make sense of by themselves. Regarding the types of infographics defined by Colle (2004), this infographic would fall on the category of the first-level infographics, as it is the most complete type of infographic – with a title, text and illustrations, and with the distintice feature of text on the side or separated from the illustrations. On another note, this also is a science communication infographic, as it contains scientific content that intends to be transmitted, while also being a journalistic infographic (Colle, 2004).

OCEANOS

Um oceano de plástico

O problema está a atingir proporções gigantescas: todos os anos, vão parar aos oceanos entre cinco e 13 milhões de toneladas de plásticos, concluiu um estudo recente na revista *Science* com dados sobre 192 países costeiros.

TERESA FIRMINO e **CÉLIA RODRIGUES** · 18 de Fevereiro de 2017, 19:13 *(actualizado a 18 de Fevereiro de 2017, 19:24)*

2542 PARTILHAS

Figure 6 – Page one of the original infographic.

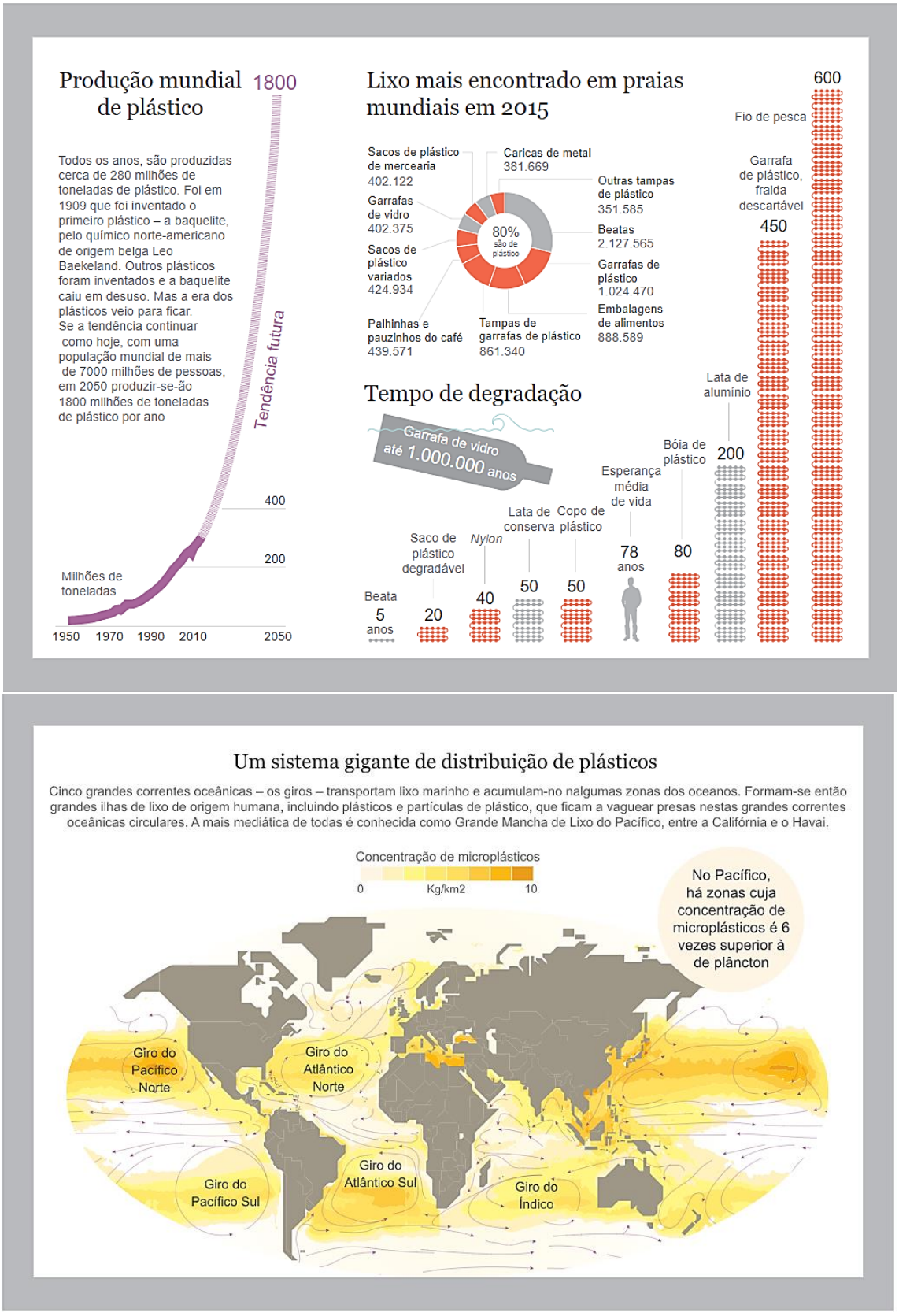


Figure 7 – Pages two and three of the original infographic.

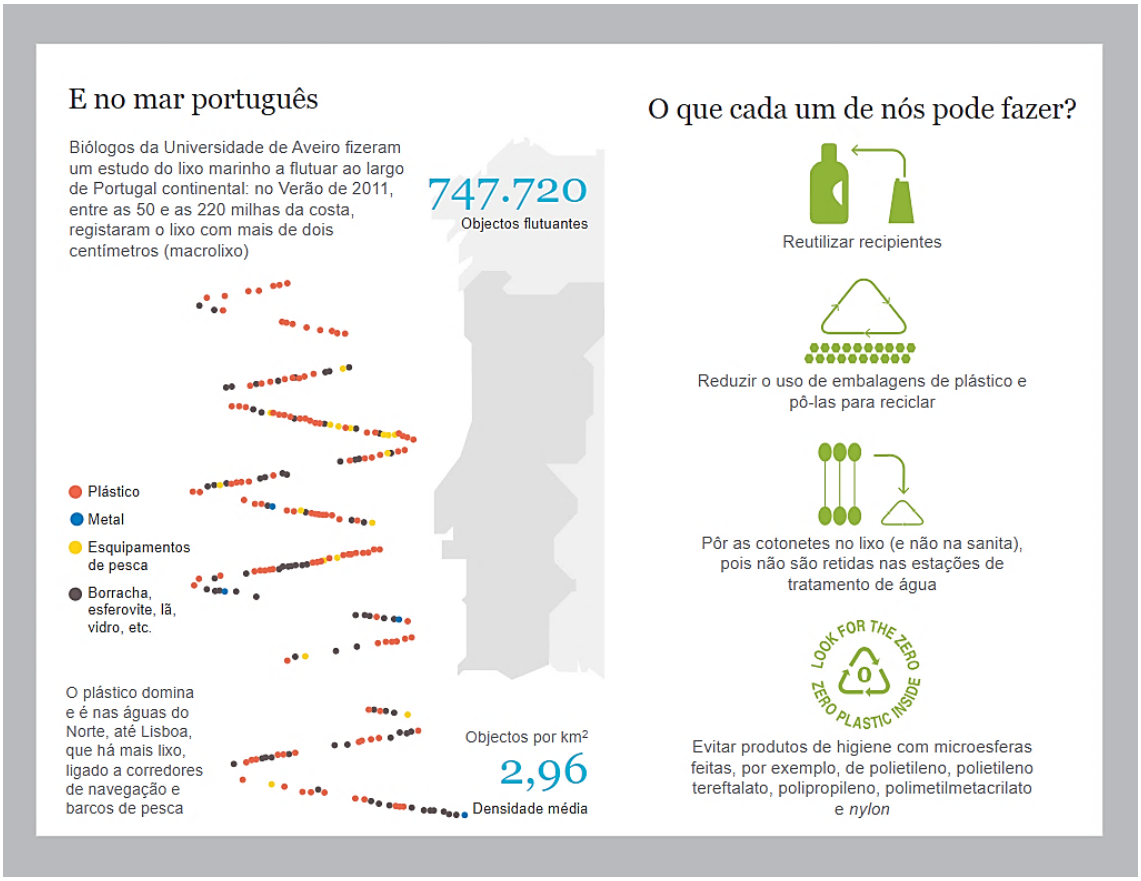


Figure 8 – Page four of the original infographic.

3.1.2.2 Redesigned Infographic

Using the original infographic, designed by *Público,* as a basis and taking into consideration the results obtained for the already existent social representations in our group of participants, the process of redesign was carried out to create the redesigned infographic.

The redesigned final product had the overall same navigation and structure of the original infographic, as changes occurred mainly at the level of the internal organization of the infographic pages, and in their content. The four-square links at the top of each infographic page were maintained (Figure 9), although their names were changed, and a feature of marking the page in which the user currently is was added, via a colorization of the square link of that page. Also, a feature of progression to the next pages of the infographic was added at the end of each page, in order to facilitate the navigation through the infographic piece.

A reorganization of content was also carried out during the redesign process, to make the narrative of the infographic clearer and, also, to take into consideration that, for instance, not all

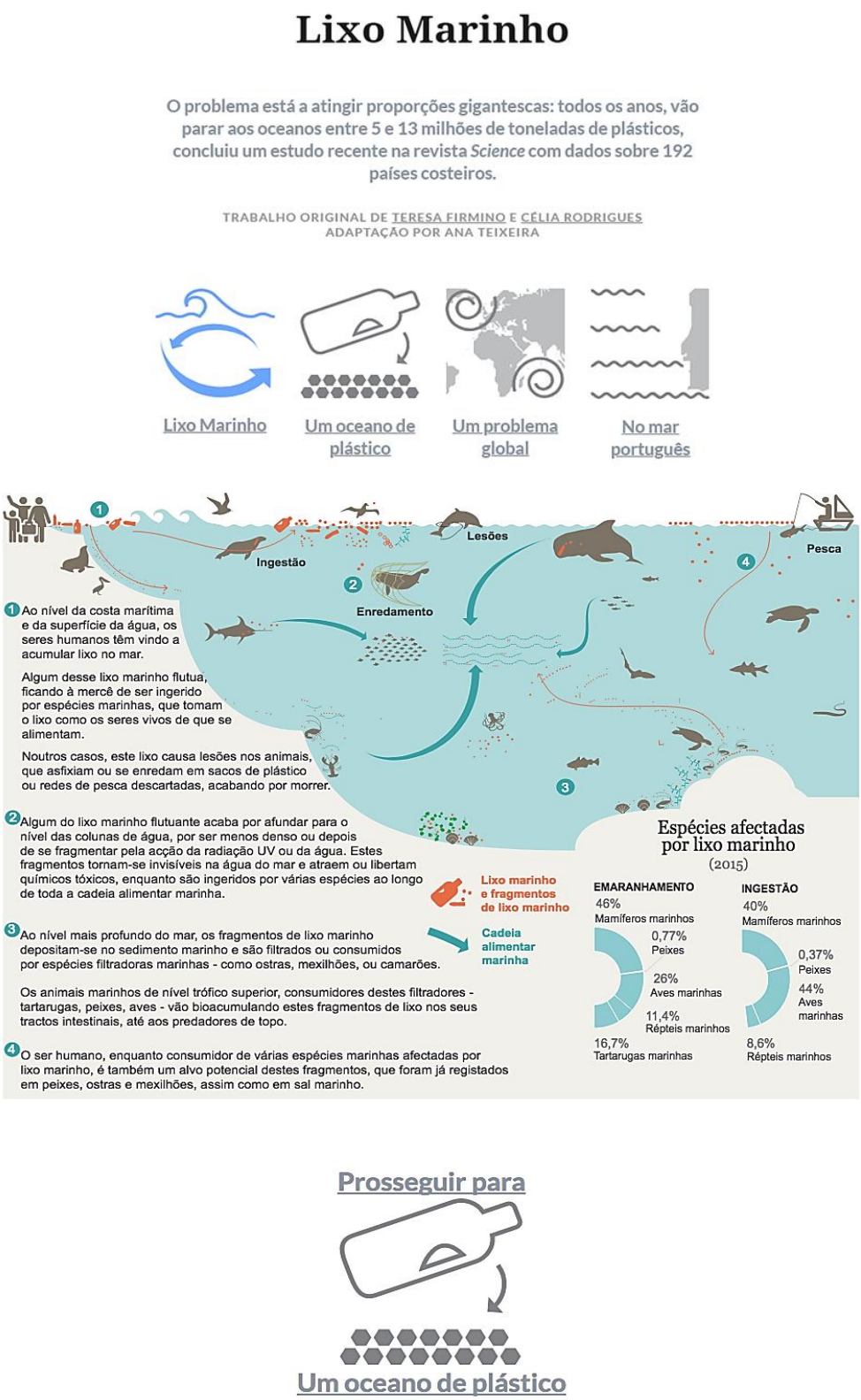


Figure 9 – Page one of the redesigned infographic.

participants immediately associated marine litter with plastics or with marine animals; essentially, instead of mentionging marine litter, plastics, microplastics, effects on marine species all at once and in a single page, the content was subdivided, according to the following:

1. Page one should focus first on Marine Litter as a whole - its origins, consequences, and ubiquos presence both outside and inside the ocean, and along the maritime food chain, in which humans are included. These alterations intended to incorporate results from the social representations on environment/nature and on marine litter, where it was understandable that participants were not looking at humans as a cause/victim of marine litter or as *in* the environment/nature, as much as *against* the environment/nature;

2. Page two should present plastic as the main component of marine litter, as well as present the reasons for it – data on plastics production, plastics disposal by country, plastics degradation times, and focusing on most commonly found plastics objects within marine litter; this incorporation intended to enhance the already presence of plastics in participants' social representations on marine litter, but also to add this term within the participants who didn't right away associated plastics with marine litter;

3. Page three intended to introduce the concept of microplastics, as well as their invisible but massive contribution to marine litter around the entire planet, while also explaining how marine litter navigates through the ocean currents, creating "garbage patches" in convergence zones; this incorporation came from the results on social representations of marine litter and plastics, which revealed that participants were not associating them with microplastics;

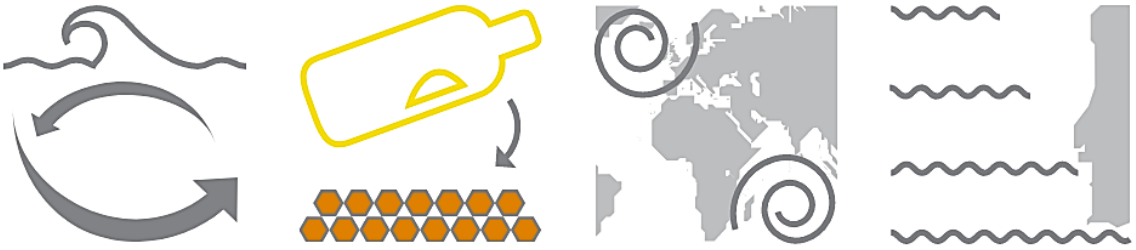
4. As in the original version, this page intended to focus on Portugal and the already registered presence of marine litter at the Portuguese coast, as well as present some measures that can be adopted in order to fight marine litter.

The first page – "*Lixo Marinho*" ["Marine Litter"]– (Figure 9) presented a simplified and slightly altered version of the graphic depicting the origins, circulation and effects of marine litter through the marine water levels and marine species, but now the text box only mentioned aspects related with this same topic, complementing better the graphic, while the smaller graphic about marine species affected by marine litter by ingestion and entaglement was maintained. Pointers to each level of the ocean were added and complemented with text paragraphs, in an attempt to describe the ubiquity of marine litter throughout all ocean levels and the major consequences at that level (1 – maritime coast and sea surface; 2 – water columns; 3 – deep sea and sea floor; 4 – back at the ocean surface and water collums).

The most important addition to this page was that of the human species as both the origin and one of the final targets of marine litter consequences on marine environment. As discussed

before, the notion of humans as possible victims or actors on marine litter was not proeminent in obtained representations. Also, the elements of "fishing" and "fishing nets" was sometimes present in our obtained representations, as if participants associated fishing activities with a source of marine litter, and not as a result of their own actions as well. Taking these results into account, the depiction of a man fishing was added, with a dual purpose – first, it demonstrates how humans can be affected by marine litter, for instance, by fishing marine animals that contain microplastics in their guts (Karami *et al*., 2017; Wagner *et al*., 2014); secondly, it also depictes how humans are the one who create marine litter, for instance, by fishing, since fishing gear is one of the most common objects found polluting ocean waters (UNEP & GRID-Arendal, 2016). Humans were also added at the initial point of the cycle of marine litter, enhancing the role of human mismanagement of litter as the main source of marine litter.

The second page – "*Um Oceano de Plástico*" ["Plastic Ocean"] (Figure 10) focused only on the topic of plastics, and their bigger contribution to marine litter; graphics depicting predicted future plastics production, more common plastic items found on beaches and degradation times of plastic objects were maintained with small alterations on color palletes - more yellows were used for this page, as participants referred to associate this color with "plastics" – and some alterations on aggregation of items referred in the graphics, in order to highlight items that were referred by participants as representative of "plastic", such as plastic lids, plastic bottles, or plastic bags. The textual element on this page was enlarged, in order to adittionaly include a description of the connection between "petroleum" and plastics and marine litter, as this was a frequent term that arrised within the analysed social representations. The notion that a very small portion of disposed plastics are actually being recycled was also included in the text, as participants made a frequent connection between "recyclying" and "plastics", but the fact is that still 80% of all plastics are not being recycled nor even incenerated – they are being left in the environment (Geyer *et al*., 2017), and participants did not seem aware of it.



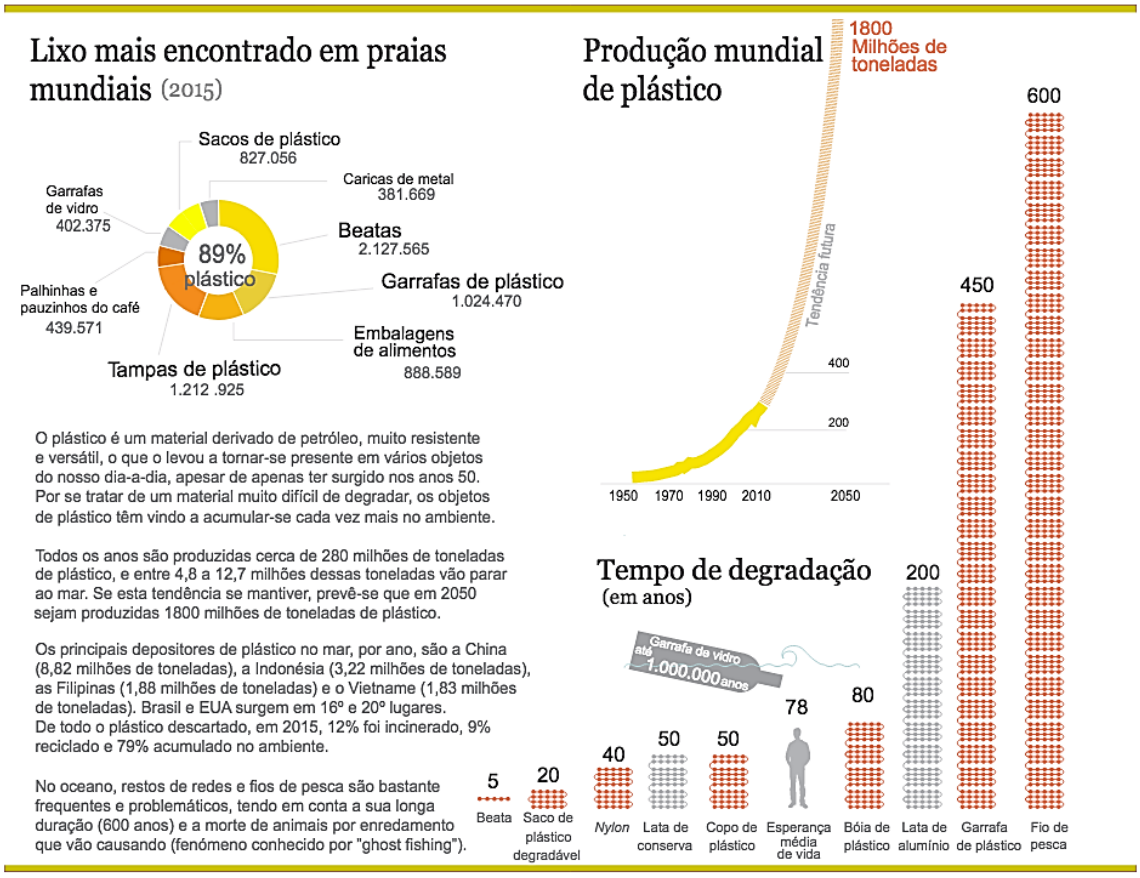


Figure 10 – Page two of the redesigned infographic.

The third page – "*Um Problema Global* ["A Global Problem"] – (Figure 11) was the most different from the original version, as it now included a new graphic representative of most common – and most mentioned by participants as their representations of "plastics" – plastic objects that contribute to marine litter, and comparasions between them in terms of size and visibility/invisibility under water. This addition intended to highlight the role of microplastics on marine litter, since such an element was not being found on the social representations of participants. Also, by using plastics objects that are already known within the social group – like

"glitter" it should be easier for them to understand the concept of microplastics and their invisibility under water. The graphic depicting the five ocean gyres was maintained but reduced and complemented with a text box that explained the concept of microplastics and of ocean gyres, as well as presented them as carriers of marine litter all around the globe, accumulating floating and visible but also non-floating and non-visible plastic litter in convergence zones.

Finally, the fourth and last page – "*No Mar Português*" ["In the Portuguese Sea"] – (Figure 12) did not suffer major alterations from the original page, only small adjustments were made to the graphic depicting the most common objects found within Portuguese coastal marine litter, highlighting with yellow tones all the objects derived from plastics in order to bring more attention to those, and an addition of an textual element that brings a bigger focus on microplastics in the Portuguese waters, and that was not present in the original version. This focus on the marine litter found in Portuguese waters was felt important, in order to fight the tendency of participants to look at the marine litter problem as a "*distant problem that is only affecting marine animals*". Also, on the section related with pro-environmental actions, the green color was kept present and more highlighted, as participants frequently associated this color with "nature/environment". More examples of actions were added, in order to bring attention to the fact that plastic items – again, most mentioned plastic items mentioned by partipants were used - are all around us in our

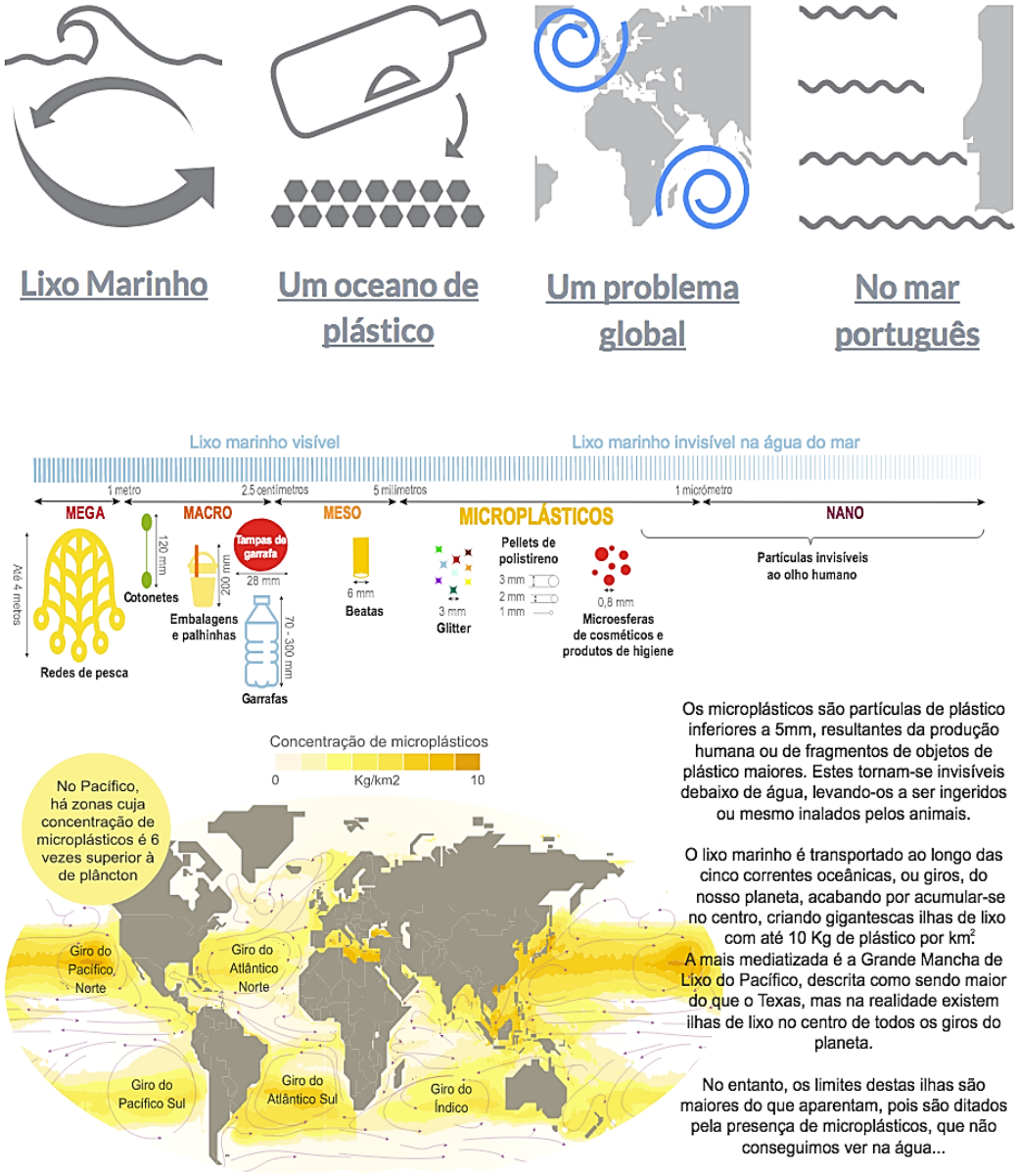


Figure 11 – Page three of the redesigned infographic.

daily life, and so many of them can actually be either refused, reused or recycled, by just taking small actions everyday.

3.1.2.3 Adapted Questionnaire for Elaboration Levels' Measuring

Data gathering was carried on using the same questionnaire as the one described on Empirical Study One, but with a few additions, in order to gather more data on persuasion levels from participants. These additions included three questions. The two first ones were questions

Figure 12 – Page four of the redesigned infographic.

related with perceived relevance and interest of the viewed infographic (possible answers rating from one ("Not relevant/interesting at all") to seven ("Very relevant/interesting") (Park, 2011) (Appendix B – Added Questions for Gathering of Persuasion Levels).

Previous studies examining messages, cognitive responses, and attitudes regarding behavior change have found that participants who received personally relevant messages list more positive thoughts than those who did not receive personally relevant messages, and this was correlated with a significantly higher intention for behavioral change, but, at the same time, total number of thoughts and negative thoughts did not significantly differ based on type of message received (Parker, 2011). Taking such into account, the total number of thoughts listed by participants was measured using a thought listing task following the visualization of the infographic, as well as the total number of positive and negative thoughts. The included thought-listing question asked participants to list all their thoughts after viewing the infographic, as well as to rate each thought as either positive ("Message portrayed was good"), negative ("Message portrayed was bad") or neutral (Park, 2011; Shen & Seung, 2018). Thought listing questions have in fact revealed to be

the best solution to measure persuasion on studies related with persuasive messages, when compared to self-report questions, which seem to be better suited for entertainment-related information (Shen & Seung, 2018).

3.1.3 Procedures

Procedures undertaken on the several steps of the investigation will be discussed in the next sections. First, a description of the procedures regarding the obtaining of permission to redesign the infographic, the finalization and the publication of this new infographic will be discussed; later, procedures regarding data gathering and data analysis will be presented.

3.1.3.1 Permissions, Redesign and Publication

Prior to the all alterations, the original authors of the infographic published at *Público* were contacted by email in order to obtain their permission to use and edit their work. After such permission was granted, the redesign process took place.

The redesigning was carried out using the vector graphic editor software *Adobe Illustrator*, developed by Adobe Systems (https://www.adobe.com/products/illustrator.html), with all initial and final graphic objects being Scalable Vector Graphics (SVG), which, consisting of an XML-based vector image format for two-dimensional graphics with support for interactivity, allowed for vector editing, better adaptation of the final product to all screens and to all major web browsers, as well as for the attainment of good final graphic quality.

After its completion, the redesigned product was published online following the same structure of the previous infographic, although not as a one-piece Hypertext Markup Language (HTML) and Cascading Style Sheets (CSS) final product - as the investigator was not experient with such languages - but instead as an online publication with four pages in fact separated, as the publication occurred using WordPress, the popular and leading open source content management system (CMS). Wordpress is currently a technology used in more than 25% of all web-sites, as it helps and facilitates the development and management of websites and online content for audiences without knowledge of programming or design expertise (Habib, 2018). A previously existent online community of teachers and investigators focused on sharing research related with multimedia for science learning and teaching – *mCiências* (http://spq-ffms.spq.pt/) – was where the online publication of the infographic took place (http://spq-ffms.spq.pt/lixo-marinho).

3.1.3.2 Data gathering and Data analysis

Participants were gathered as previously mentioned in the first empirical study – both casually at the bar of the Faculty of Arts, during class breaks, and during free intervals of on-

going classes, in which the professors allowed the investigator to collect data. Participants were randomly assigned to each condition, which was attained by rolling a dice before each attribution of questionnaire (if the number was even, the participant would read the original infographic; if the number was odd, the participant would read the redesigned infographic). After delivering the questionnaire, the investigator freely left the participant to read the infographic - while remaining close in case of any doubts – and, after the visualization, the partipant would answer the questionnaire. Participants read the infographics either on their smartphones or in their personal computers.

Data collected through the thought-listing tasks was first analysed via cognitive coding procedures, which occurred in four steps:

1. The investigator divided the data into psychological thought units;
2. The investigator classified each thought unit either as relevant or irrelevant (related with message or message format were relevant – all the others were not);
3. The investigator classified all relevant thought units either as indicative of central processing (if related with the message (marine litter and plastics)) or as indicative of peripheral processing (if related with the message format) (Parker, 2011; Shen & Seung, 2018);
4. Finally, the investigator also classified each thought unit (central or peripheral) as either positive, negative or neutral, using for this step the assumptions of Shen & Seung (2018) about the valence of generated thoughts.

Data on the representations generated by word/stimulus marine litter and plastics, after infographic processing, was also analysed. Both words “marine litter” and “plastics” were analysed as one, as the answers for both were very similar and both were central aspects on the infographic’s content viewed. A content analysis was carried out, which intended to find, among all answers, terms related either with “human (ir)responsibility” or with “consequences for humans”, as well as with “microplastics” and “plastics”. Only in the case of the count of the term “plastics” we looked at marine litter as a single word/stimulus. The presence and/or absence of such terms was registered and their frequencies in both experimental situations compared to check significant differences.

After this analysis, descriptive statistics and independent-samples t-test or Pearson's chi-square were applied to the quantitative data collected, using the SPSS statistical software. We used an alpha level of .05 for all statistical tests.

3.2 Results

Results will be presented by each infographic experimental situation, with alternating focus on each component analysed for the verification of variations within the levels of persuasion in

each situation – knowledge scores on marine litter, attitude towards marine litter and generated thoughts. Also, results on perceived relevance and interest of each infographic will be presented. Finally, we will present compared results on the representations of marine litter/plastics, after infographic processing.

3.2.1 Experiment with Infographic Design One: *Original*

Results will be present first in relation with Knowledge Scores on Marine Litter, followed by Attitudes towards Marine Litter and, finally, on Generated Thoughts. Also, the results on perceived relevance and interest of the infographics will be presented.

3.2.1.1 Knowledge Scores on Marine Litter

Medium scores that were obtained by participants that processed the original infographic and later answered a series of questions related with marine litter were situated around 7 (M = 6.60; SD = 1.99), which was half of the maximum score for this scale; that is, the mean grade was just between a positive (more than 7) and a negative (less than 7) score on the test.

3.2.1.2 Attitudes towards Marine Litter

Mean results for the two final factors of the attitudinal scale on marine litter were of M = 6.70; SD = 0.45 – that is, between "Agree" and "Strongly agree" responses - for *Indignation towards Marine Litter,* and M = 4.90; SD = 1.22 – that is, "Partially agree" response - for *Pro-Environmental Behavior Habits*.

3.2.1.3 Generated Thoughts

Results on generated thoughts are described on Figure 13. The total number of thoughts generated for the processing of the original infographic was 91, which comprised 69 central

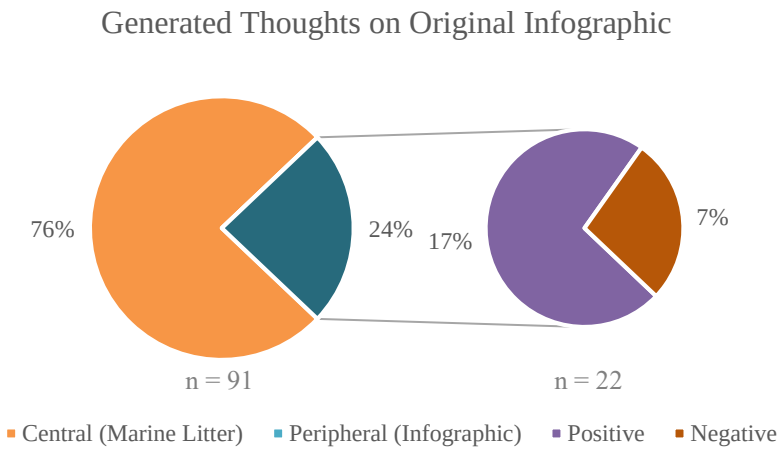


Figure 13 – Generated thoughts after original infographic processing.

(related with marine litter) and 22 peripheral (related with message format) thoughts. No negative thoughts on marine litter (central negative thoughts) were registered, so all central thoughts were positive ("*I didn't know the dimensions of the damage that plastic is having on the oceans.")*. Regarding the infographic, a total of 6 negative thoughts ("*The content was confusing and particularly not appealing.*") were registered, all the 16 others being positive ("*The graphics and the images help understanding*").

Although observed means (Table 18) on this situation showed to be unfavorable, in comparison to those of the redesigned infographic situation, there were no statistically significant differences between means of generated thoughts of both situation, for all compared t-tests.

Table 18 – Compared results (means and standard deviations) of generated thoughts.

Generated thoughts	Experimental situations	Mean (*SD*)
Total generated thoughts	Redesigned	3.84 (*1.90*)
	Original	3.32 (*1.80*)
Central thoughts	Redesigned	3.00 (*2.00*)
	Original	2.44 (*1.60*)
Peripheral thoughts	Redesigned	0.84 (*1.30*)
	Original	0.88 (*1.30*)
Peripheral positive thoughts	Redesigned	0.64 (*1.10*)
	Original	0.76 (*1.30*)
Positive thoughts	Redesigned	3.64 (*2.00*)
	Original	3.00 (*1.90*)
Negative toughts	Redesigned	0.20 (*0.80*)
	Original	0.32 (*0.80*)
Peripheral negative thoughts	Redesigned	0.20 (*0.80*)
	Original	0.12 (*0.40*)
Central positive thoughts	Redesigned	3.00 (*2.00*)
	Original	2.44 (*1.60*)

3.2.1.4 Relevance and Interest

Perceived relevance and perceived interest of the infographic viewed by each participant was registered and analysed. One participant, out of the 25 gathered for this experimental situation, didn't answer this question of the questionnaire. For the original infographic, mean relevance was 6 (M = 6.04, SD = 1.20), that is, only one value below the maximum answer. As for the mean interest, mean answer was also 6 (M = 5.71, SD = 1.43), but closer to 5, that is, two to one value below the maximum answer.

3.2.2 Experiment with Infographic Design Two: Redesigned

Results will be present first in relation with Knowledge Scores on Marine Litter, followed by Attitudes towards Marine Litter and, finally, on Generated Thoughts. Also, results on perceived relevance and interest will be presented.

3.2.2.1 Knowledge Scores on Marine Litter

Medium scores obtained by participants that processed the redesigned infographic and later answered a series of questions related with marine litter were situated around 7 (M = 7.28; SD = 2.49), which was half of the maximum score for this scale; that is, the mean grade was just between a positive (more than 7) and a negative (less than 7) score on the test. While this mean on total scores was higher (+0.68) than the one verified for the original infographic processing, they weren't found to be significantly different. That said, additional comparisons between the experimental situations were performed in order to better investigate these differences. After a chi-square test that compared all scores for both experimental situations, significant results were found, $\chi 2$ (9, N = 50) = 20.19, p = .017, which were favorable to the redesigned situation. Also, results were later divided by the middle possible score for the knowledge scale (below 6.5 and above 6.5), that is, between a "negative" and a "positive" grade, and in this situation comparison of results revealed marginally significant differences, $\chi 2$ (1, N = 50) = 3.13, p = .077, which were also favorable to the redesigned situation. Compared results on Stem-and-Leaf plots between the redesigned and the original infographic processings (Figure 14) reveal a higher reduction of possible scores within a smaller group, composed exclusively of positive scores. Such reduction was not verified for the original infographic scores. A considerable reduction on standard deviations was also verified, for both experimental situations. Negative outliers, however, were verified for the redesigned situation, but these were also compensated by the presence of of positive outliers.

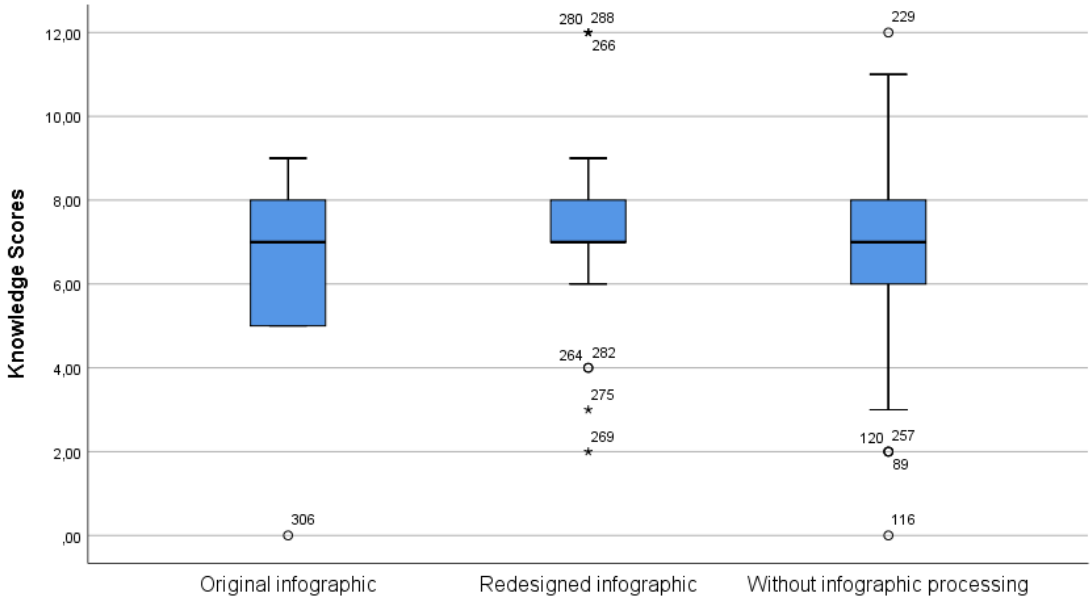


Figure 14 – Compared results of Stem-and-Leaf plots on knowledge scores for three experimental situations – after original infographic processing; after redesigned infographic processing and without any infographic processing.

3.2.2.2 Attitudes towards Marine Litter

Mean results for the two final factors of the attitudinal scale on marine litter were of *M* = 6.70; *SD*= 0.50 – that is, between "Agree" and "Strongly agree" responses - for *Indignation towards Marine Litter*, and *M* = 5.00; *SD* = 0.99 – that is, "Partially agree" response - for *Pro-Environmental Behavior Habits*. These were the almost exact same results verified for the original infographic processing, so no variations on attitudes were verified between experimental situations.

3.2.2.3 Generated Thoughts

Results on generated thoughts for the redesigned infographic are described on Figure 15. The total number of thoughts was 96, which comprissed 75 central and 21 peripheral thoughts. No negative thoughts on marine litter (central negative thoughts) were registered, so all central

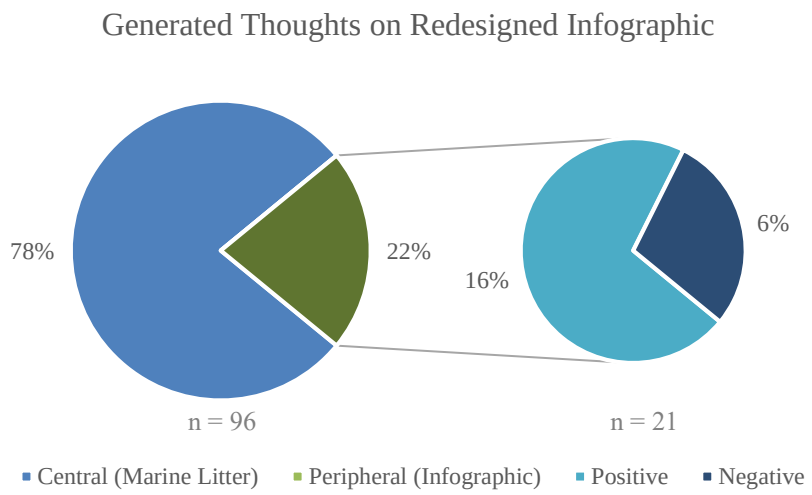


Figure 15 – Generated thoughts after redesigned infographic processing.

thoughts were positive ("*Global pollution is not being taken seriously*."). Regarding the infographic related thoughts (peripheral), a total of 6 negative thoughts ("*Too much text.*") were registered, all the 15 others being positive ("*Using colors for every page makes reading pleasanter.*"). Mean values between the redesigned and the original infographic can be consulted on Table 18. Although the observed means for the redesigned situation showed to be favorable, when compared with the original situation, there were no statistically significant differences found between all types of generated thoughts for both situations.

3.2.2.4 Relevance and Interest

Perceived relevance and perceived interest of the infographic viewed by each participant was registered and analysed. One participant, out of the 25 gathered for this experimental situation, did not answer this question of the questionnaire. For the redesigned infographic, mean relevance was 6.25 (*SD* = 0.74), that is, one value below the maximum answer, and with an increase of 0.21 from the original infographic situation. As for the mean interest, mean answer was also 6 (*M* = 6.13, *SD* = 0.85), but with an increase of 0.42 when compared with the previous situation. Although it was verified that both relevance and importance answers were superior on the redesigned situation - the biggest increasing happening on the interest answers – these differences were not found statistically significant, *t* (46) = -1.22, n.s., for compared interest, and *t* (46) = -0.73, n.s., for compared relevance.

3.2.2.5 Compared Results on Social Representations of Marine Litter/Plastics

After content analysis of all answers gathered on the adjoined word/stimulus marine litter and/or plastics, all answers which were related either with "human (ir)responsibility", "consequences for humans", "microplastics" and "plastics" were analyzed. Answers related with "human (ir)responsibility" brought terms like "capitalism", "production", "individualism", "irresponsibility", "development" or "man". Answers related with "consequences for humans", on the other hand, brought terms like "health", "problem", "food" and "diseases". Answers for both "microplastics" and "plastics" were considered whenever they appeared. As for answers regarding "plastics", these were only considered when they appeared within the question about the word/stimulus "marine litter".

Regarding the term "human (ir)responsibility", we found the same number of participants who mentioned the term in both experimental situations. As for the term "consequences for humans" (Figure 16), in the experimental situation of the redesigned infographic there were 13 participants who mentioned the term; nearly the double of the number of participants who mentioned the same term in the original infographic situation (7). After statistical analysis, this difference was found to be marginally significant, $\chi 2$ (1, N = 50) = 3.00, *p* = .083 (Figure 16). The term "microplastics" came up on the answers of 3 participants within the original infographic experimental situation, while in the redesigned situation, it was mentioned only by one participant. These differences were not found significant, $\chi 2$ (1, N = 50) = 1.09, *p* = .50. The term "plastics" was mentioned by 14 participants who viewed the redesigned infographic, against 13 times by participants who viewed the original infographic. This difference was also not significant, $\chi 2$ (1, N = 50) = 0.08, *p* = .77.

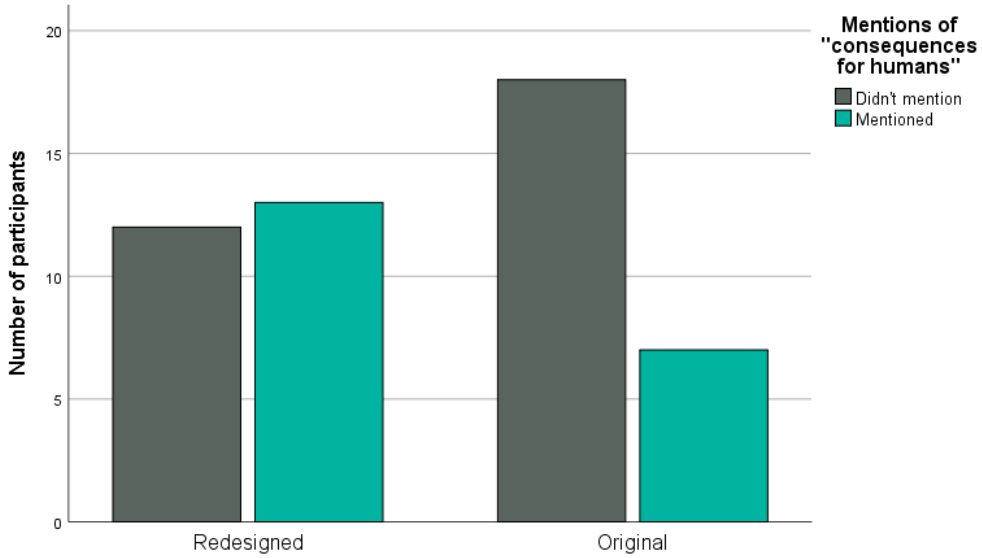


Figure 16 – Compared results on the number of participants that mention "consequences for humans" for the representation of marine litter/plastics, after infographic processing.

3.3 Discussion

After a previous study on the social representations on marine litter, plastics and environment/nature within the social group of undergraduated Art students, an original infographic developed by a Portuguese newspaper team was used as a basis for a redesign process of the infographic content in order to attend to such gathered representations. Later, a study on the changing of attitudes, knowledge scores, and overall persuasion levels after two experimental situations was conducted – after original infographic processing and after redesigned infographic processing.

Results on knowledge scores on a previously developed scale of 14 questions related with marine litter and regarding the information that was depicted on both infographics revealed statistically significant differences between scores of the two experimental situations, being favorable to the redesigned situation. Nevertheless, the mean scores did not differ greatly, with the redesigned situation having a higher mean score, but still being of about seven for both – that is, only half of answers right, which reveals a lack of retention and/of attention to the infographics, as they presented all the information to get right all the 14 answers, but that never happened. It was expected that by recurring to participants social representations on the redesigned infographic, the persuasion levels were increased and a greater elaboration on the content of the redesigned infographic will cause participants to pay more attention to the information presented, therefore, being able to answer the knowledge scale more correctedly - this was met, but not fully,

as mean differences weren't relevant. This could be explained by a previous knowledge of the topic within participants, which might have compensated a lack of attention or persuasion to the content either on the original infographic, either on the redesigned one, or even increased the scores on participants who weren't fully engaged in infographic reading – as they already knew some things, they answered correctdly anyway. The currently frequent coverage of the topic of marine litter in the news and social media might certainly contributed to this influence on previous knowledge on the topic (Brownlow, Honeyborne, & Fothergill, 2017; PlasticOceans, 2018; National Geographic, 2018; Parker *et al*, 2018; Zachos, 2018).

Results on attitudes towards marine litter that made use of a previously developed attitudinal scale and its indicators *Indignation towards Marine Litter and Pro-Environmental Behavior Habits* revealed a slight decrease on the mean of the indicator *Indignation Towards Marine Litter*, which nevertheless remained at the "Agree" position, with a tendency for the "Strongly agree" position, when compared with the results after the original infographic processing; in the case of the second indicator a small increase was verified, but not relevant, as both experimental situations revealed means that were situated on the "Partially agree" position.

In fact, at least on the indicator *Pro-Environmental Behavior Habits,* this lack of difference is understandable, as it refers to behaviors that were already present before the processing of the infographics, and that wouldn't be changed immediately after viewing any of the infographics, so in fact this indicator would anyway tell little about the persuasion of the infographic piece and of its message on changing pro-environmental habits on participants – to verify such changes, the study would have to be made some time after the time of the processing of the infographics. As for the inexistence of differences on the factor *Indignation towards Marine Litter*, the lack of effect produced by either of the infographics processing could be explained by an already very marked attitude prior to any infographic processing, leaving little room for big changes on this indicator. As the topic of marine litter has been frequently and increasingly reported on the news and in social media (*Mais de 90% do lixo marinho encontrado nas praias portuguesas é plástico*, 2016; Parker *et al*, 2018; National Geographic, 2018; PlasticOceans, 2018), as well as in the political spheres, including in Portugal (Cardoso, 2018), and such *boom* on communications about marine litter was happening while the results were being gathered, both attitudes and knowledge on the topic were being also increasingly developed and, so, less prone to changes.

Results on generated thoughts showed higher mean numbers of total, positive and central thoughts for the redesigned infographic situation, but differences were found not significant. A prevalence of central thoughts (related with message content) was found on both situations, also in this case, being higher for the redesigned situation, but without significant difference. Positive thoughts have proven to be of particular relevance for evaluating message elaboration, although the total number of thoughts is also a good indicator (Parker, 2011; Shen & Sheun, 2017). Both of these were higher for the redesigned infographic (96 and 78, comparing with 91 and 73 for the

original infographic), but these differences were not significant. Although there are indications of higher persuasion for the redesigned infographic situation, these differences were not significant between experimental situations, which doesn't go in line with the marginally significant differences on knowledge scores, discussed earlier, but do go in line with the lack of differences for attitude changes. Results, however, seem to agree with previous studies which have shown that infographic messages promote high elaboration levels (Lazard & Atkinson, 2015).

Results on relevance and interest of the infographic message perceived by participants revealed no significant differences between experimental situations, although values were slightly superior for the redesigned infographic. Such results reveal a lack of increased meaning of the redesigned infographic for participants, which wasn't expected to happen, after the inclusion of gathered social representations on its design. In both situations, the mean answer for relevance and also for interest was 6, that is, only one position below the maximum answer. Although these results reveal a general interest of participants on the topic of marine litter and on the infographic messages, there wasn't a preference for one of the infographic designs. According to Petty & Cacioppo (1986), the factor motivation or interest of individuals on the persuasive messages in a step that can lead to greater elaboration levels during message processing and, as results reveal, participants did seem motivated to processing the message, but as their motivation was equal for both experimental situations, so did the measured levels of persuasion in terms of generated thoughts. Nevertheless, positive tendencies to greater effects of the redesigned infographic were verified, and the significant positive effect on retention of information – which also contributes to the motivational component of the ELM – adds up to this tendency of increased perceived relevance and interest as an indicative of greater motivation and/or persuasion towards the redesigned infographic.

Results revealed that the social representations of participants on marine litter/plastics, after viewing the redesigned infographic, were more associated with "consequences for humans" that those who viewed the original infographic. Therefore, there is a possibility that the redesigned infographic had an effect of changing the perception on the marine litter topic as a problem that is more related to humans, as the pre-infographic-viewing social representations were not associating marine litter with consequences for humans, but instead only with consequences for marine species. The same cannot be said in relation with the term "human (ir)responsibility; the mentions of this term were equal for both cases. The effect of the incorporation of more information on "microplastics", in order to overcome a lack of mention of this term on participants' social representations, did not generate the desired effects, as this term was more mentioned within the participants who saw the original infographic than within those of the redesigned one. Also, "plastics" were not more frequently mentioned on participants who saw the redesigned infographic than within those who saw the original one, but nevertheless, plastics was very frequently mentioned (in both cases by 60% of participants), which indicates that they did perceived this material as prevalent within marine litter after both processing situations, or that

they already had this idea present before readind any of the infographics. When we compare this result with the one obtained for the pre-processing representation on marine litter (present within 12% of the answers), however, we verify that the mention of "plastics" was not so frequent as it was in after both experimental situations. Therefore, the high increase of frequency for the mention of "plastics" within marine litter seems to indicate that both infographic designs were equally effective on highlighting the role of plastics for marine litter. However, the alterations during the redesign process on the aspect of stressing the role of plastics did not produced better effects on changing the representation of marine litter on this aspect. In sum, only in the case of "consequences for humans" we verify marginally significant changes in social representations, within participants who viewed the redesigned infographic But, then again, this was the main intervention in terms of social representations that we intended to act on, during the redesign process. According with the work of Salesses (2005), changes on the social representations have an effect on the changing of attitudes, as both are interdependent; also, changing attitudes being the ultimate goal of persuasive communication, we can say that if there is operated a change on the social representations of participants after they processed a persuasive message, then it must have had effects at the persuasion level. This can be said, however, only in relation with the term "consequences for humans"; for all other ones analysed results were not significant, which could be due to an ineffective inclusion of these elements on the redesigned infographic, to an inexistent effect on persuasion levels, or to the previously existence of this element on the representation, as it was verified on the results from study one.

3.4 Summary and Conclusions

Two experimental situations of infographic processing were created and conducted in order to investigate if attending to the social representations on marine litter of a specific social group, during the redesign of a persuasive message, increased individuals' levels of persuasion when they were processing this message, when compared to a situation in which such representations had not been considered while designing a persuasive message.

Results showed mostly non-significant differences between experimental situations, except for compared knowledge scores and compared post-processing social representations on marine litter (although only marginally significant). Nevertheless, other results, on compared number of generated thoughts or compared perceived relevance and importance of the message for participants, revealed positive tendencies for the redesigned infographic. Only attitudes towards marine litter did not change at all between experimental situations.

Significant differences between the knowledge scores of both experimental situations were described, favorable to the redesigned condition. This result goes in line with expected higher

scores for this situation, as the usage of social representations during the redesign process was expected to add increased meaning for participants, and, therefore, to cause that the information depicted would be retained more easily. Also, this increased attention and/or retention of information has been described as a step on the road to central processing, in the ELM model and, therefore, as an indicative of increased persuasion on the redesigned infographic group.

Results on attitudes towards marine litter weren't altered by the processing of the redesigned infographic; both situations revealed an agreement with *Indignation towards Marine Litter* and a partial agreement with *Pro-Enviromental Behaviors*. Such lack of differences could be explained either by a non-immediate effect of the persuasive messages (Lima, 2004), or by a previous very marked opinion towards this topic, therefore not leaving much room for stronger changes on this indicator, which could be promoted by the increasing attention that has been being brought on the topic of marine litter in the news and social media.

Although there were no significant differences between experimental situations, total number of thoughts, central thoughts and positive thoughts were greater on the redesigned situation, again revealing a tendency favorable to this condition. Nevertheless, on both situations of infographic processing there was a prevalence of central thoughts, which agrees with literature that states the promotion effect of the infographic format on higher elaboration levels (Lazard & Atkinson, 2015).

Perceived relevance and interest of the infographic message also didn't demonstrate significant differences between experimental situations, which goes against predicted outcomes, as the inclusion of social representations on the redesigned message was expected to increase the meaning of the message to participants. Nevertheless, both results revealed a high interest of participants on the topic of marine litter.

Results revealed that the social representations of participants on marine litter/plastics, after viewing the redesigned infographic, were more associated with "consequences for humans" that those from the situation of viewing the original infographic. Therefore, there is a possibility that the redesigned infographic had an effect of changing the perception on the marine litter topic as a problem that is more related to humans, as the pre-infographic-viewing social representations were not associating marine litter with consequences for humans, but instead only with consequences for marine species. This alteration on the representation of marine litter is indicative of increased persuasion on the redesigned group of participants. Other analysed terms ("human (ir)responsibility", "microplastics" and "plastics") however, did not show significant differences.

In conclusion, all indicators of persuasion used did present positive tendencies towards an effect of the redesign process on incrementing persuasion, but only one of the results was significant, and only marginal significances were found on the mentioning of "consequences for

humans" amongst post-processing representations on marine litter. That said, the hypothesis that elaboration levels of participants would be higher when they processed a redesigned message that attended to their social representations on marine litter, in comparison to a situation in which such message hasn't been redesigned, was not fully supported.

4. General Discussion

This work intended to put science communication into practice, using multimedia infographics as a communication format for conveying information on the environmental topic of marine litter. Supported by the theoretical fundations of the Social Representations theory (Moscovi, 1961) and of the elaboration likehood model for persuasive communication (Petty & Cacioppo, 1986), two empirical studies have been put into practice; while the first intended to gather the social representations on marine litter, plastics, environment/nature and infographics within our group and to gather their attitudes towards marine litter and towards the infographic format, the second study intended to make use of gathered social representations in order to understand if using those during the design of an infographic message could increase persuasion levels on participants and/or change their attitudes towards the topic.

Our hypothesis was that when we communicated the scientific theme of marine litter while taking in consideration the social representations of our audience about that theme, we would obtain greater levels of elaboration from participants, when compared to the situation in which the communication of the same scientific theme did not consider their social representations.

As a result, our research questions were the following:

- What are the social representations of participants about the environmental theme of marine litter and about infographics?
- What are the attitudes of participants on the marine litter topic, and on infographics?

During the first empirical study, we studied current social representations and attitudes on the marine litter topic, but also on infographics. For this effect, we developed two new attitudinal scales, one for each topic of research.

The developed attitudinal scale on infographics revealed excellent internal consistency, therefore proving to be a valuable resource for present and future studies on attitudes towards infographics, as there is currently a lack of this type of scales that focus on this multimedia format. This scale proved to be effective on gathering information on indicators *Importance and Advantages of Infographics*, *Infographics Reading Habits* and *Liking of Infographics Reading*, which are consistent with the ABC model of attitude's components that served as a basis for its creation (Rosenberg and Hovland's, 1960).

Newly-developed attitudinal scale on marine litter proved to have good internal consistentcy and revealed the indicators *Indignation towards Marine Litter* and *Pro-Enviromental Behavior Habits*. These resulting factors did not find the three expected components of attitudes proposed by Rosenberg and Hovland's (1960), but instead seemed to join the cognitive and affective components into a single factor – *Indigantion towards Marine Litter*. The behavioral component, however, was clearly identified on the other factor *Pro-Enviromental Behavior Habits*. This scale also comprises a valuable resource for future investigation on the attitudes of public audiences towards the environmental case of marine litter, as, to the moment, no other scale has been developed specifically towards this topic. Since the 1970s, researchers have been interested in knowing how public audiences are creating attitudes towards several environmental topics (Castro, 2005). During this work, we felt that the most commonly used scales for the evaluation of environmental attitudes within individuals - such as the scale for the measurement of ecological attitudes and knowledge by Maloney, Ward, and Braucht (1975), the scale for environmental concern by Weigel and Weigel (1978) and the NEP scale by R. E. Dunlap and Van Liere (1978) - were not ideal for being used in this study, due to their strong ideological assumptions and also to their mentions of environmental problems that are not so relevant nowadays. Therefore, this new developed scale, which is focused in a relevant environmental topic of today, and for today's public audiences, gains value by being more specific and less ideological in its measures. That said, this new scale on environmental attitudes might be just one more amongst all the other ones that have been being developed since the 1970s, but nevertheless, its specificity on a very recent and increasingly important topic gives it relevance, as it also serves as an example for the development of future other scales on attitudes towards the environment.

These new scales have thus helped us to bring answers to the two research questions of this work:

- What are the social representations of participants about the environmental theme of marine litter and about infographics?
- What are the attitudes of participants on the marine litter topic, and on infographics?

Regarding participants attitudes obtained through these scales, we observed that attitudes towards marine litter showed that while participants are strongly agreeing that there is in fact a environmental problem and that such problem should be addressed (high agreeance with *Indignation towards Marine Litter*), their actions are not agreeing with their ideias, as they demonstrated low pro-enviromental behavioral habits (neutral concordance with *Pro-Environmental Behavior Habits*). These results agree with literature on the frequently incoherent relationship between attitudes and behaviors (Lima, 2004), and specifically on the case of environmental attitudes and pro-environmental behaviors (Wiegel and Newman, 1976). Also, the strong position of indignation towards the marine litter case agreeds with an increasingly pro-ecological/NEP attitude, from the part of society, towards the environment (Dunlap & Van Liere, 1978; Castro, 2005; Scharmer & Kaeufer, 2013). The high values of interest and of relevance that

were verified for both experimental situations also agree with this generalized look on marine litter as a "tragic" problem, even if it is still not being very associated with humans – which also reveals that today's public, at least amidst the young participants of our study, look at the environment as something that is important, which has been prevalent since the first environmental studies of the 1970s (Castro, 2005).

Attitudes towards infographics revealed neutral positions towards this multimedia format except on the indicator *Infographic Reading Habits* (mean of "Partially disagree") which explains the two other results on *Importance and advantages of Infographics* and *Liking of Reading Infographics* (both with means of "Partially agree"). These results thereby confirm the lack of familiarity with infographics within participants that was verified also for the studies on infographics' social representation. These results have, therefore, revealed unexpected outcomes, which add importancy to this work, as it was able to identify a lack of knowledge and familiarity with a multimedia format that was been thought as generally known, even if in at a superficial level, amongst the public (Krum, 2013; Dunlap & Lowenthal, 2016). This increased knowledge on attitudes towards infographics is valuable for the infographics/multimedia field of research; by knowing what the public knows and thinks about these multimedia formats, researchers are able to better design and plan communicational strategies for the future, either by wanting to increase the knowledge about this format, by using it more, either by avoiding difficulties on communicating with the public that isn't familiar with this format, by not using it at all.

Results on social representations have revealed that participants are already building social representations on the topic of marine litter, which are being centered around the term "death", associated with the terms "pollution", "plastics", "marine species" and "petroleum", therefore proving that the recently frequent exposition of this topic on the news (*Mais de 90% do lixo marinho encontrado nas praias portuguesas é plástico*, 2016; Parker *et al*, 2018; National Geographic, 2018) have been making the topic familiar within participants. Nevertheless, the representations that are being built do not enphatize the role of humans on both as an origin and as a victim of this environmental problem, which is also related with the way the topic is depicted in some of the news about it, which focus on dead or trapped animals (Ruiz-Grossman & Dahlen, 2017; Zachos, 2018). The emergence of "plastics" on the representation of marine litter tells us that some participants are already associating marine litter with plastic, the most frequent component of marine litter (Galgani *et al*., 2015; UNEP & GRID-Arendal, 2016). The social representation of plastics, however, is not being directly associated with marine litter, but instead with "pollution", and secondarily with "garbage", "everyday objects" and "recycling", which nevertheless shows that participants are realizing the harmufness of plastics for the environment (Cózar *et al*., 2014; Wagner *et al*., 2014; Geyer *et al*., 2017), although not specifically for the oceans.

Regarding the social representation of infographics, the study revealed a relevant lack of experience and knowledge of this communication format within participants, as 53% of them didn't know what infographics were, which contradicts the popularity of this format (Dunlap & Lowenthal, 2016) at least within our group of participants. Nevertheless, amongst participants who did know what infographics were, the representation is being build around "information", associated with either "imagetics", "graphics", and "dissemination", which does agree with the denotative meaning of an infographic (Krum, 2013; Polman & Gebre, 2015), but relies too much on a tautology of terms, therefore proving the incipiency of this representation on the social group.

The second empirical study on compared persuasion levels of an original infographic about marine litter and of a redesigned infographic that incorporated the gathered social representations in its content revealed some significant differences on persuasion levels between situations. However, most differences only showed positive tendencies favorable to the redesigned situation, and not significant differences. This study, therefore, didn't fully support our hypothesis:

> When we communicate the scientific theme of marine litter while taking in consideration the social representations of our audience about that theme, we obtain greater levels of elaboration from participants, when compared to the situation in which the communication of the same scientific theme doesn't consider participant's social representations.

The redesign process offered new insights on how to adapt the communication of an environmental and/or scientific topic, and to adapt an infographic piece, to the pre-existent representations on the topic within participants. After the results from the study one, it was evident what changes should or shouldn't be performed – what participants already had well present, and what they hadn't.

Only changes that were related with the previously gathered social representations were made, in order to make sure that the results we were to get would be due to these changes. Due to this, the final product included only little differences, in comparison with the original infographic, but even with these small changes, we could still see that some results in regard to persuasion were obtained, which highlights the possible effective role of social representations on increasing both meaning and persuasion on science communication practices, or in multimedia communications as a whole.

It was expected that by recurring to participants social representations on the redesigned infographic, the persuasion levels were increased and a greater elaboration on the content of the redesigned infographic will cause participants to pay more attention to the information presented, therefore, being able to answer the knowledge scale more correctedly – these results were verified, as mean differences between experimental situations were significant. When we compare these results with the control situation (no infographic processing, $M = 6.50$; $SD = 1.99$), we realize the

changes on mean answers were almost not present, which is also indicative that participants did have previous knowledge on the topic of marine litter, and such had influence in balancing results for both experimental situations. Nevertheless, Figure 14 made clear that on the redesigned situation answers were more concentrated on the same values (which were positive, superior to the half of the final score), and that the *SD* reduced greatly from the control situation. Moreover, also in the situation of the original infographic processing there was expected to occur an increased mean score, when compared with the control situation, as all the information to answer correctedly was also in this infographic, but such didn't happen, as we actually obtained a lower mean score (-0.27) for this case than for the case on no infographic processing. Nevertheless, there was a positive difference from the control situation to the redesigned infographic situation in terms of mean scores, even if a small one (+0.68 in mean scores); and this, added to the significant difference on compared knowledge scores for both experimental situations reveals that the redesigned infographic was more effective in retaining information on participants, thus increasing motivation in the chain of processes that lead to higher levels of elaboration (Petty & Cacioppo, 1986). Existent models on persuasive communication have emphatized the role of attention and retention of messages, within a 5-step chain of processes, for persuasion to take place (Lima, 2004), while later models, such as the Heuristic-Systematic model (Chaiken *et al*., 1989) and the elaboration likehood model (ELM) (Petty & Cacioppo, 1986) stand by a route to persuasion which can be made via short-cuts and skip some of these steps – the peripheral route to persuasion. In this case, however, this increased attention to the redesigned infographic did seem to promote persuasion via central routes, as when we compare these results with the results obtained for the generated thoughts, which were highly central for both situations, but, again, with greater results for the redesigned infographic, we understand that the higher retention of information or attention to the content on the redesigned infographic seems to have had an influence on increasing elaboration levels on participants.

Results also revealed a lack of effect, of any infographic processing situation – control, original and redesigned - on the changing of attitudes towards the marine litter topic. But, as the *Indignation towards Marine Litter* mean levels already had revealed high concordance before any infographic processing (M = 6.46; SD = 0.68, between "Agree" and "Strongly Agree" mean positions), there wasn't actually much room for a change on this indicator. That is, without seeing any infographic, participants already revealed very high responses of indignation towards marine litter, which certainly results from the frequent mention of this topic in the news and social media (*Mais de 90% do lixo marinho encontrado nas praias portuguesas é plástico*, 2016; Parker *et al*, 2018; National Geographic, 2018). Nevertheless, for both infographic processing situations, there was an increase +0.2 on the mean response, which is a small variation, but might, however, indicate a positive effect of infographics for persuasion (Lazad & Atkinson, 2015). As for the indicator *Pro-Environmental Behavior Habits*, as it focused on pre-existent habits, it wasn't expected to change right after infographic processing, and indeed, it didn't change relevantly,

remaining at the "Partially agree" position for all situations – control with $M = 4.92$; $SD = 1.12$, increase of +0.1 in mean response for both the original infographic and the redesigned infographic. As the effect of persuasive messages are often not immediate (Lima, 2004), later data gathering from participants could have been a better option to evaluate a possible change on attitudes towards marine litter. In this case, again, a non-significant change on attitudes towards marine litter indicate that the elaboration levels were low, as weaker and less enduring attitudes generally result from lower levels of persuasion/elaboration (Petty & Cacioppo, 1986), while the high number of central thoughts registered for either situation of infographic processing indicate central and higher levels of elaboration. Nevertheless, the attitudes towards marine litter could already been well cimented before the experimental study took place, and so they were less prone to change.

Generated thoughts analysis revealed that both situations had similar elaboration results, with 76%-78% of generated thoughts revealing a processing through the central route of elaboration. That, nevertheless, reveals overall high persuasion levels during both infographic designs processing, which proves the efficacy of this format in promoting high elaboration levels. These results go in line with the efficient power of infographic as persuasive messages as studied by Lazard & Atkinson (2015). Again, a slightly more positive tendency towards the redesigned infographic was verified, revealing a tendency to increased persuasion. We can also look at the results from perceived relevance and interest of the infographic message as indicators of a tendency of both infographics and of the redesigned infographic to increase persuasion, as also in this measure results were favorable to the redesigned condition, although not significantly. It has been explained how motivation, which includes interest for the topic portrayed, is the first a step towards persuasion, either in high or low elaboration levels, in the ELM (Petty & Cacioppo, 1986). By revealing such high responses for perceived interest and relevance of both infographic messages, participants are revealing motivation to engage in central processing, as it was verified during the analysis of generated thoughts. So, even if differences are not significant amongst experimental situations, there is evidence on the role of infographics for persuasive communication. Also, such high motivation from participants to process the topic of marine litter could have had the effect of defusing the differences between experimental situations, as participants could have been so focused on the overall topic, that they failed to notice the details that were distinctive of each infographic.

Analysis of the social representations after infographic processing allowed to verify changes in social representations operated by the infographic message, in comparison with the social representations obtained for the first empirical study. Studying these changes in social representations is important for this work because of Salesses (2005) and Moscovici's (1961) conclusions on the interdependence and circular relationship between social representations and

attitude – by changing social representations, we are changing attitudes, that is, we are persuading (Lima, 2004), in more of less extension.

Results revealed that the social representations of participants on marine litter/plastics, after viewing the redesigned infographic, were more associated with "consequences for humans" that those from the situation of viewing the original infographic. Therefore, there is a possibility that the redesigned infographic had an effect of changing the perception on the marine litter topic as a problem that is more related to humans, as the pre-infographic-viewing social representations were not associating marine litter with consequences for humans, but instead only with consequences for marine species. This process of change in the social representations of marine litter/plastics moved from "*something that pollutes and kills marine animals*" to "*something that pollutes and kills marine animals, possibly affecting humans as well*". These changes on social representations are possible through a process of anchoring that uses old representations in order to create new ones – assimilation (Vala & Monteiro, 2004). In view of these results, we could say, therefore, that in this work we used social representations to change social representations, and through these changes, we changed attitudes/persuaded our participants.

In conclusion, all indicators of persuasion used did present positive tendencies towards an effect of the redesign process on incrementing persuasion, but only one of the results was significant, and only marginal significances were found on the mentioning of "consequences for humans" amongst post-processing representations on marine litter. That said, the hypothesis that elaboration levels of participants would be higher when they processed a redesigned message that attended to their social representations on marine litter, in comparison to a situation in which such message hasn't been redesigned, wasn't fully supported, and more studies are necessary to arrive at a stronger conclusion.

5. Conclusions

This work has contributed for a better understanding of the role of multimedia infographics and of social representations to science communication practices, in terms of message persuasion levels. Through a first study on the social representations of undergratuated students from Arts related with marine litter and with infographics, and a second study on the variation of persuasion levels on participants who read a redesigned infographic that incorporated the obtained representations on marine litter or that read an infographic which was not redesigned, we gathered results that contribute for the knowledge on both infographic communication and science communication.

Social representations on marine litter were found already present on participants, being centered around “death” and associated with “pollution”, “plastics”, “marine species” and “petroleum”. Attitudes on marine litter revealed that while participants are concerned with the topic, they are not engaging on pro-environmental behaviors.

Social representations and attitudes on infographics were found very undeveloped, with 53% of participants affirming that they don’t know what an infographic is; attitudes revealed no habits of reading this format, and so, consequently, very neutral other attitudes towards this communication format were verified. Still, on participants who knew what it was, the social representation was centered on “information” an associated with “imagetics”, “graphics”, and “dissemination”.

We hypothesized that a redesigning process of the original infographic would conduct to increased levels of persuasion on participants, when compared to the processing of the original infographic. Although all indicators of persuasion used did present positive tendencies towards an effect of the redesign process on incrementing persuasion, significant results were only those related with increased knowledge scores and effective changes on the representation of marine litter/plastics. That said, the hypothesis wasn’t fully supported, and more studies are necessary to arrive to stronger conclusions.

This work has offered some insights for the multimedia and infographics area of research, by providing and studying ways of incorporating social representations and the study of attitudes within its methods. As Lankow *et al.* (2012) mentioned, a *good infographic* is one that is *sound* – that is, that communicates something meaningful for an audience. Hence the importance, applied in our work, of considering participants social representations while designed or redesigning multimedia infographic pieces – or other multimedia formats -, in order to improve their quality and significance, by improving their meaning for the desired audience. As infographics are in fact a format that uses representations in its core, in order to simply, make more accessible and accelerate the process of communication, it seems that social representations are in fact an only natural way of increasing their effectiveness of communication. As in the area of multimedia communication for scientific purposes, the advantages for communication of environmental topics through infographics had already been explored, with the work of Lazard & Atkinson (2015). Our work also proved this format to be ideal for such cases, as participants revealed high interest and high persuasion when viewing both infographics. Also, the developed attitudinal scale proved to be effective in studying and gathering results regarding how participants were looking at infographics.

Contributions to the area of science communication were also relevant. Farr (1993) had already mentioned the necessity for science communication (particularly the one that is focused on PUS) to invest on connections with the social representations theory, as it will both benefit scientists/science communicators and public audiences. First, it will benefit science communicators in knowing more about the ways the public is understanding and creating attitudes towards science, therefore helping to design and plan adapted ways to reach public audiences – as it was performed during our redesign process. Secondly, it will benefit the public, as since they have their understanding and views on science known, they will receive personalized and adjusted communications that will ultimately improve all of the AEIOU desirable personal responses to science (Burns *et al*., 2013). In fact, when we consider the definition of science communication of Burns et a. (2013), "the use of appropriate skills, media, activities, and dialogue to produce one or more of the AEIOU (the vowel analogy) personal responses to science", we can look at this work and at the gathering of existent social representations on public audiences that we carried out as, more or less, like a form of indirect dialogue with a public audience that permitted to adapt media to more effectively developing awareness and understanding of science amongst our participants. Also, if we question ourselves about the effectiveness of such effort in terms of communicating science, we would answer with a "Yes", as results did show effects in both knowledge improvement and attitude changing, regarding the scientific topic of marine litter.

As for contributions of the study for the study of environmental attitudes and of environmental communication/persuasion, results on the final attitudinal scale towards marine

litter and of social representations did prove to be effective in understanding the way participants were looking at the topic of marine litter, as well as to design interventions via multimedia to improve or correct obtained results, while also creating conditions for high levels of elaboration when processing such messages.

5.1 Constraints and Future Work

Time constraints accelerated the redesign process, which could have been more developed in order to more strongly enhance the gathered social representations of participants in the redesigned infographic, as such could have produced more significant differences amongst experimental situations. Also, a bigger number of participants for the experimental study might have helped to better perceive the differences among experimental situations. Data gathering on the change of attitudes towards marine litter might have showed stronger results if done sometime after infographic processing, instead of immediately after.

Future works to be done includes a deeper study on the utility of social representations for both infographic and scientific communication, including deeper changes on the design of the infographics, in order to better perceive if the role of social representations'inclusion becomes more evident.

Also, results from this study on infographics' lack of familiarity amongst universitary students will be useful for further investigation and actions regarding this multimedia format. The same can be said regarding the results on participants' social representations on infographics and marine litter.

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Appendices

Appendix A - Final Questionnaire for First Empirical Study

Questionário sobre a temática do Lixo Marinho

(Teixeira, A., Morais, C., & Moreira, L. - 2018)

Este questionário demora apenas cerca de 11 minutos a responder e tem por objetivo conhecer as suas representações sobre o lixo marinho. Leia com atenção as questões que se seguem e responda de acordo com o que pensa, sente ou faz. Não há respostas boas, nem respostas más. Por favor, responda a todas as questões pela ordem de apresentação. As suas respostas são rigorosamente anónimas. A qualquer momento poderá contactar os investigadores e colocar qualquer questão acerca da presente investigação através do e-mail: ***anasofiapdedc@gmail.com***. Muito obrigado pela colaboração.

1. Indique cerca de CINCO palavras ou ideias que lhe vêm à mente quando pensa em **plásticos**:

2. Indique cerca de CINCO palavras ou ideias que lhe vêm à mente quando pensa em **ambiente/natureza**:

3. Indique cerca de CINCO palavras ou ideias que lhe vêm à mente quando pensa em **lixo marinho**:

4. Indique cerca de CINCO palavras ou ideias que lhe vêm à mente quando pensa em **infografia**:

5. Por favor, **ordene as palavras ou ideias que indicou nas questões anteriores por ordem de importância** (1- mais importante a 5 - menos importante). Utilize para o efeito a coluna da direita de cada um dos quadros de palavras ou expressões acima.

Atitudes em relação ao Ambiente

Por favor, leia as afirmações pela ordem de apresentação. Indique, com um X, o seu grau de concordância com cada uma das afirmações seguintes de acordo com a escala:

1. **Discordo fortemente**
2. **Discordo**
3. **Discordo em parte**
4. **Não concordo nem discordo**
5. **Concordo em parte**
6. **Concordo**
7. **Concordo fortemente**

1. Aprecio o mar e o ambiente marinho em geral.	1	2	3	4	5	6	7
2. Encaro a quantidade de lixo atualmente presente no mar como um assunto importante.	1	2	3	4	5	6	7
3. Costumo deitar lixo para o chão ou para a água quando frequento ambientes aquáticos.	1	2	3	4	5	6	7
4. Seria capaz de alertar outras pessoas para que NÃO poluíssem as praias ou a água do mar.	1	2	3	4	5	6	7
5. Gosto de saber que estou a agir em prol de um futuro ambiente marinho menos poluído.	1	2	3	4	5	6	7
6. Sou da opinião de que a presença de microplásticos em produtos de higiene pessoal deveria de ser proibida ou evitada.	1	2	3	4	5	6	7
7. Preocupa-me que alimentos provenientes do ambiente marinho possam conter microplásticos.	1	2	3	4	5	6	7
8. Saber que existem grandes ilhas de lixo marinho ao longo do planeta é algo que me perturba.	1	2	3	4	5	6	7
9. Para mim é inaceitável que ao ingerir peixe ou sal marinho poderei estar a consumir resíduos de lixo marinho.	1	2	3	4	5	6	7
10. Procuro reutilizar e/ou reciclar o plástico que consumo no dia-a-dia.	1	2	3	4	5	6	7
11. Procuro informar-me sobre a composição ou características dos materiais que compõem os produtos que compro diariamente.	1	2	3	4	5	6	7
12. Penso que é da responsabilidade do ser humano preservar o ambiente marinho para as futuras gerações.	1	2	3	4	5	6	7
13. O facto de que os plásticos atualmente presentes no mar poderão lá permanecer ao longo do tempo de vida dos meus filhos e netos é algo que NÃO me afeta.	1	2	3	4	5	6	7
14. Incomoda-me quando vejo que a água do mar ou as praias que frequento estão poluídas.	1	2	3	4	5	6	7
15. O sofrimento dos animais marinhos devido ao emaranhamento ou à ingestão de plásticos marinhos é algo que me perturba.	1	2	3	4	5	6	7
16. Saber da presença de microesferas de plástico em produtos de higiene ou beleza NÃO me impediria de os comprar.	1	2	3	4	5	6	7

17. Estaria disposto (a) a juntar-me a iniciativas de apanha de lixo marinho nas praias.	1	2	3	4	5	6	7
18. Gostaria que as minhas praias ou rios favoritos NÃO se encontrassem poluídos, no futuro.	1	2	3	4	5	6	7
19. A morte ou sofrimento de animais devidos á existência de lixo marinho é algo que considero que NÃO deveria acontecer.	1	2	3	4	5	6	7
20. Preocupa-me que a tendência crescente de produção de plásticos e a crescente população humana venham a piorar a questão do lixo marinho.	1	2	3	4	5	6	7
21. Sou a favor de que se deve agir contra o incremento do lixo marinho no nosso planeta.	1	2	3	4	5	6	7
22. NÃO costumo tomar atenção á quantidade de plástico que consumo e/ou desperdiço diariamente.	1	2	3	4	5	6	7
23. NÃO me perturba saber que a água do mar possa estar poluída globalmente por pequenas e impercetíveis partículas plásticas.	1	2	3	4	5	6	7
24. Procuro consumir produtos menos prejudiciais para o ambiente.	1	2	3	4	5	6	7
25. Se porventura produzo lixo junto à praia, apanho-o e deito-o num contentor apropriado.	1	2	3	4	5	6	7
26. Procuro informar-me sobre que medidas posso tomar para reduzir a minha contribuição para a poluição ambiental.	1	2	3	4	5	6	7
27. Faço separação do lixo em minha casa.	1	2	3	4	5	6	7
28. A preservação do ambiente marinho é um tema importante para mim.	1	2	3	4	5	6	7
29. Incomoda-me quando me alertam para ter cuidado com o lixo que produzo na praia ou na água.	1	2	3	4	5	6	7
30. Considero preocupante se vier a saber que posso ser um (a) consumidor (a) de alimentos que possuem plásticos provenientes de lixo marinho.	1	2	3	4	5	6	7
31. Considero que a questão do lixo marinho é uma questão relevante para a nossa sociedade atual.	1	2	3	4	5	6	7

Atitudes em relação a Infografias

Por favor, leia as afirmações pela ordem de apresentação. Indique, com um X, o seu grau de concordância com cada uma das afirmações seguintes de acordo com a escala:

1. **Discordo fortemente**
2. **Discordo**
3. **Discordo em parte**
4. **Não concordo nem discordo**
5. **Concordo em parte**
6. **Concordo**
7. **Concordo fortemente**

1. Sei o que é uma infografia.	1	2	3	4	5	6	7
2. Procuro ler infografias relacionadas com os meus temas de estudo e/ou de interesse pessoal.	1	2	3	4	5	6	7
3. No meu dia-a-dia gosto de consultar informação sob a forma de infografias.	1	2	3	4	5	6	7
4. Tento procurar por infografias relacionadas com os meus temas de estudo.	1	2	3	4	5	6	7
5. Sinto que a informação transmitida através de uma infografia é incompleta.	1	2	3	4	5	6	7
6. Tenho por hábito ler infografias.	1	2	3	4	5	6	7
7. Uma infografia NÃO é um método eficaz de comunicar informação aos leitores.	1	2	3	4	5	6	7
8. Considero que é importante saber ler e interpretar eficazmente informação transmitida sob a forma de uma infografia.	1	2	3	4	5	6	7
9. Penso que as infografias adicionam qualidade comunicativa quando acompanham texto.	1	2	3	4	5	6	7
10. Considero que as infografias deviam ser mais utilizadas para comunicar informação.	1	2	3	4	5	6	7
11. A minha facilidade em interpretar uma infografia depende do tema da mesma.	1	2	3	4	5	6	7
12. Ao consultar infografias, procuro explorar todo o seu conteúdo.	1	2	3	4	5	6	7
13. Penso que as infografias são um meio de comunicação muito apelativo visualmente.	1	2	3	4	5	6	7
14. Quando me deparo com infografias, online ou impressas, evito lê-las.	1	2	3	4	5	6	7
15. Sinto-me mal informado (a) quando leio infografias.	1	2	3	4	5	6	7
16. Penso que as infografias são um meio útil para transmitir informação de forma sintetizada.	1	2	3	4	5	6	7

17. Acho importante que os media apostem mais em infografias para comunicar melhor com as suas audiências.	1	2	3	4	5	6	7
18. Acho importante que a comunicação científica aposte mais em infografias para comunicar melhor com as suas audiências.	1	2	3	4	5	6	7
19. Raramente leio infografias.	1	2	3	4	5	6	7
20. NÃO gosto de ler infografias.	1	2	3	4	5	6	7
21. Considero que as infografias possam facilitar a compreensão de tópicos complexos e abstratos, como alguns temas científicos.	1	2	3	4	5	6	7
22. Se obtiver a mesma informação sob a forma de texto e sob a forma de uma infografia prefiro ler o texto do que a infografia.	1	2	3	4	5	6	7
23. Se obtiver a mesma informação sob a forma de texto e sob a forma de uma infografia prefiro ler a infografia.	1	2	3	4	5	6	7
24. Se obtiver a mesma informação sob a forma de texto e sob a forma de uma infografia prefiro ler ambos.	1	2	3	4	5	6	7
25. Procuro habitualmente por infografias nos sites e nos jornais que costumo ler.	1	2	3	4	5	6	7
26. Considero que desenvolver a capacidade de leitura de uma infografia em estudantes seja algo importante.	1	2	3	4	5	6	7
27. NÃO me agrada que cada vez mais encontre infografias na informação que consumo online.	1	2	3	4	5	6	7
28. Quando me deparo com uma infografia, sinto-me tentado (a) a lê-la.	1	2	3	4	5	6	7
29. Considero que as infografias permitem consumir informação de forma mais fácil e percetível.	1	2	3	4	5	6	7

30. No último mês quantas infografias leu?

Zero	1 a 3	4 a 6	Mais de 6

31. Qual o grau de dificuldade que sente ao interpretar uma infografia? (**1 = Muito Facilmente, 2 = Facilmente, 3 = Nem facilmente nem dificilmente, 4 = Dificilmente, 5 = Muito Dificilmente**).

1	2	3	4	5

1. Já ouviu falar da temática do Lixo Marinho? **Sim** ☐ **Não** ☐

2. Se respondeu **Sim**, através de que canais ouviu falar desta temática?

Internet	
Televisão	
Jornais ou Revistas	
Meio académico	
Rádio	
Em conversa casual	
Outro	Qual?

Por favor, leia as afirmações pela ordem de apresentação e escolha entre as opções de resposta aquela que considera a resposta **mais acertada**, rodeando a alínea. Escolha **apenas uma** resposta.

1. Qual dos itens abaixo considera como o maior perigo associado à presença de Lixo Marinho e, em particular, com a presença de plásticos, nos cursos de água?

a) Emaranhamento de espécies animais em plásticos e outros objetos.

b) Redução do turismo em zonas com mais lixo acumulado.

c) Passagem de partículas de lixo marinho ingeridas - plástico em particular - ao longo das cadeias alimentares, podendo chegar os humanos.

d) Ingestão de macro e micro plásticos pelas espécies animais que frequentam esses cursos de água.

e) Não sei.

2. Qual pensa ser o tipo de lixo mais comum entre o Lixo Marinho?

a) Plástico.

b) Vidro.

c) Papel.

e) Resíduos alimentares.

d) Não sei.

3. O que entende por microplásticos?

a) Partículas de plástico inferiores a 5mm, dificilmente percetíveis a olho nu, especialmente se debaixo de água.

b) Objetos de plástico de menores dimensões.

c) Partículas plásticas completamente invisíveis ao olho humano.

e) Fragmentos resultantes da quebra de plásticos maiores.

d) Não sei.

4. Qual pensa ser a principal fonte de Lixo Marinho?

a) Má gestão de resíduos de origem humana.

b) Lixo resultante da atividade animal marinha.

c) Deposição direta de lixo no mar, por mão do Homem.

e) Resíduos de produtos cosméticos e higiénicos.

d) Não sei.

5. Quantas toneladas de plástico considera que são produzidas mundialmente, atualmente, durante um ano?

a) 5 milhões de toneladas por ano.

b) 100 milhões de toneladas por ano.

c) 20 milhões de toneladas por ano.

d) 280 milhões de toneladas por ano.

e) Não sei.

6. Diria que o número de toneladas de plástico produzidas anualmente terá tendência a aumentar, no futuro?

a) Não, irá reduzir-se.

b) Irá aumentar pouco, podendo chegar aos 500 milhões em 2050.

c) Sim, irá aumentar, podendo chegar aos 1800 milhões em 2050.

e) Irá manter-se.

d) Não sei.

7. Qual julga ser o principal país responsável pela deposição de plástico no mar, à escala mundial?

a) China.

b) Japão.

c) Estados Unidos.

e) Indonésia.

d) Não sei.

8. Sabendo que os microplásticos são partículas de plástico inferiores a 5mm, resultantes quer da ação humana direta, quer da degradação de partículas maiores de plástico, quais considera serem as suas principais características e perigos para o ambiente marinho?

a) Sendo de plástico, são muito difíceis de degradar, tendo tendência a acumular-se nas águas.

b) São praticamente invisíveis na água, o que os leva a serem ingeridos pelos animais.

c) Causam alergias aos banhistas, revelando-se um perigo para a saúde pública.

e) São muito leves, o que aumenta a sua dispersão ao longo das águas de todo o planeta.

d) Não sei.

9. Existirá Lixo Marinho em Portugal também? Que quantidade de objetos julga possíveis de se encontrar ao longo de um km² de mar português?

a) Sim, existe. Cerca de 50 objetos por km².

b) Não existe.

c) Sim, existe. Cerca de 3 objetos por km².

e) Existe só em alguns locais.

d) Não sei.

10. Quais julga serem os objetos mais comuns de se encontrar entre o Lixo Marinho?

a) Fio de pesca.

c) Resíduos de vestuário.

b) Sacos de papel.

d) Sacos de plástico.

e) Beatas de cigarro.

g) Embalagens de plástico.

f) Não sei.

11. Considera correto algum dos tempos de degradação destes objetos?

a) Fio de pesca: 600 anos.

c) Beatas de cigarro: 5 anos.

b) Garrafa de vidro: 1 milhão de anos.

d) Sacos de plástico – 3 anos.

e) Garrafa de plástico: 450 anos.

g) Embalagens de plástico: 10 anos.

f) Não sei.

12. O Lixo Marinho depositado em determinado local tenderá a viajar ao longo das correntes oceânicas?

a) Não, fica acumulado no local em que foi depositado.

b) Viaja, e dispersa-se pela água de todo o mundo.

c) Viaja, e acumula-se no centro destas correntes, criando ilhas de lixo.

e) Viaja, mas não muito longe.

d) Não sei.

13. Considera que os objetos plásticos depositados no mar ficam permanentemente a flutuar à superfície?

a) Sim, fragmentando-se cada vez mais.

b) Não, apenas alguns, outros descem para as colunas de água ou mesmo para o solo marinho, ou são ingeridos.

c) Não, todos eventualmente se depositam ou são ingeridos por animais.

e) Sim, ficam, e depois de fragmentados, são ingeridos por animais.

d) Não sei.

14. Que medidas considera que podemos tomar para evitar a progressiva acumulação de lixo nos nossos cursos de água?

a) Reutilizar recipientes.

c) Reciclar resíduos.

b) Utilizar apenas alguns tipos de plásticos.

d) Reduzir o consumo de plásticos de uso reduzido.

e) Usar mais vidro e menos plástico.

g) Evitar comprar produtos com microesferas de plástico.

f) Não sei.

Para nos ajudar a organizar os dados recolhidos, por favor indique:

1. Ano de Nascimento

2. Sexo

Feminino	
Masculino	

3. Curso _____ Ano curricular _____

4. Indique, rodeando o número mais adequado, quais as suas convicções políticas em relação aos seguintes pontos:

Direita	1	2	3	4	5	6	7	Esquerda
Conservador	1	2	3	4	5	6	7	Não conservador
Completamente a favor do liberalismo económico	1	2	3	4	5	6	7	**Completamente contra** o liberalismo económico

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Poderá contactar os investigadores e colocar qualquer questão acerca da presente investigação através do e-mail: ***anasofiapdedc@gmail.com***.
Obrigado pela sua participação!

Appendix B – Added Questions for Gathering of Persuasion Levels

wp.me/P8pPlm-vQ

Aceda à ligação acima e leia com atenção a infografia exposta. Tenha o cuidado de a explorar por completo, nas suas várias páginas (***Lixo Marinho***, ***Oceano de Plástico***, ***Um Problema Global*** e ***No Mar Português***). Depois de a ver por completo, por favor evite voltar a consultá-la.

Quão relevante considerou a infografia?
1 (Nada relevante) 2 3 4 5 6 7 (Muito relevante)

Quão interessante considerou a infografia?
1 (Nada interessante) 2 3 4 5 6 7 (Muito interessante)

Por favor descreva nas linhas abaixo os **pensamentos e reações** que teve em relação à infografia que leu. Descreva livremente, quer sejam reações favoráveis, desfavoráveis ou irrelevantes ao tema.
Tente inserir apenas um pensamento por linha. Seja completamente honesto e liste todos os seus pensamentos.

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

Por favor indique, em cada linha, com um **+** ou um **-**, se cada pensamento que listou foi **positivo ou negativo**. Não indique nada se foi neutro.

Um **pensamento positivo** será aquele que o levou a pensar que a mensagem da infografia é boa de alguma forma. Um **pensamento negativo** será aquele que o levou a pensar que a mensagem da infografia é má de alguma forma.